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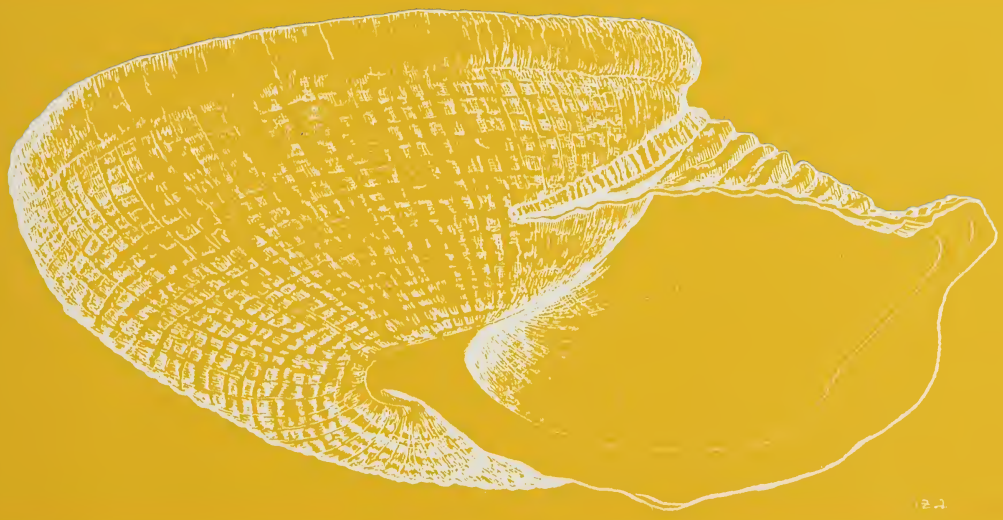

Oviedo, enero 2012

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Iberus gualtieranus (Linnaeus, 1758), una especie emblemática de la península Ibérica, que da nombre a la revista. Dibujo realizado por José Luis González Rebollar "Toza".

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The genus *Pradoxa* Fernandes & Rolán, 1993 (Gastropoda: Muricidae) in SãoTomé, Príncipe and Annobón

El género *Pradoxa* Fernandes & Rolán, 1993 (Gastropoda: Muricidae) en SãoTomé, Príncipe y Annobón

Roland HOUART* and Emilio ROLÁN**

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ABSTRACT

The genus *Pradoxa* is revised and all the species are described, compared and illustrated. Two new species are described from São Tomé, *Pradoxa gorii* spec. nov. and *P. urdambideli* spec. nov. The radula is illustrated for *P. confirmata* (Fernandes & Rolán, 1990), *P. thomensis* (Fernandes & Rolán, 1990) and *P. gorii* spec. nov. The subfamilial classification is discussed and a comparative table is added in the appendix.

RESUMEN

El género *Pradoxa* es revisado, con todas las especies descritas, ilustradas y comparadas. Se describen dos nuevas especies de São Tomé, *Pradoxa gorii* spec. nov. y *P. urdambideli* spec. nov. Se ilustra la rádula para *P. confirmata* (Fernandes y Rolán, 1990), *P. thomensis* (Fernandes y Rolán, 1990) y *P. gorii* spec. nov. La clasificación a nivel de subfamilia se discute y un cuadro comparativo se aporta en un apéndice.

INTRODUCTION

The genus *Pradoxa* was created to include two strange species, *P. confirmata* and *P. thomensis*, originally described in Buccinidae from São Tomé Island by Fernandes & Rolán (1990). However, the radula morphology (Figs. 4J-L, 5A-E) is typical for Muricidae with a rachidian tooth bearing seven cusps and denticles and with a sickle-shaped lateral tooth on each side. Both species have now been reported from Príncipe and Annobón, two other islands of the Gulf of Guinea.

Pradoxa was included by Houart (1996: 116) in the subfamily Muricopsinae, together with *Muricopsis, Favartia, Murexiella* and *Subpterynotus*, because of their almost similar radula characters. In any case, the shell morphology presents some peculiar characteristics which clearly distinguishes it from any other muricid genera and which are commented upon in the present work.

The protoconch of the genus *Pradoxa* is unusual for the family Muricidae and differs completely from any other similar genus, showing some very strong and high spiral cords separated by deep interspaces (Figs. 2E-F, 3A-H). This character is very similar in the four

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Table I. Terminology used to describe the spiral cords and the internal denticles of the outer lip (based on MERLE 1999 and 2001) (Figs 2A-D).
Tabla I. Terminología usada para describir los cordones espirales y los dentículos internos del labio exterior (basada en MERLE 1999 y 2001) (Figs 2A-D).

SP:	Subsutural cord
P1 :	Shoulder cord
P2-P6 :	Primary cords of the convex part of the teleoconch whorl
ADP :	adapical primary cord on the siphonal canal
MP :	median primary cord on the siphonal canal
ABP:	abapical primary cord on the siphonal canal
APERTURE	
ID:	Infrasutural denticle
D1 to D5:	Abapical denticles

species included in the genus (Table II). In some species of *Muricopsis*, one or two shallow spiral cords forming a shoulder may be present but never four to six cords with deep interspaces. The presence of a very small nucleus, with a diameter of 120-200 µm is another additional unusual character.

Abbreviations

IRSNB: Institut royal des Sciences naturelles de Belgique, Bruxelles, Belgium.
MHNS: Museo de Historia Natural of the University of Santiago de Compostela, Spain.
MNCN: Museo Nacional de Ciencias Naturales, Madrid, Spain.
MNHN: Muséum national d'Histoire naturelle, Paris, France.
JCD: Collection Jean-Claude Delemarre.
PR: Collection Peter Ryall.
RH: Collection Roland Houart.
SG: Collection Sandro Gori.
lv: Collected alive.
dd: Empty shell.
See Table I for additional terminology.

SYSTEMATICS

Genus *Pradoxa* Fernandes & Rolán, 1993

Paradoxa Fernandes & Rolán, 1990: 342 (junior homonym of *Paradoxa* Marshall, 1894).
Paradoxon Fernandes & Rolán, 1990: 67 (replacement name for *Paradoxa* Fernandes & Rolán, 1990 non Marshall, 1894, but junior homonym of *Paradoxon* Fleutiaux, 1903).
Pradoxa Fernandes & Rolán, 1993: 61 (replacement name for *Paradoxon* Fernandes & Rolán, 1990 non *Paradoxon* Fleutiaux, 1903).

Type species by original designation: *Paradoxa confirmata* Fernandes & Rolán, 1993, Recent, São Tomé.

Description: Shell very small, up to 5 mm in height at maturity, narrow, spire very high. Protoconch large with a small nucleus and 1.5-2.2 rounded whorls sculptured by 4-6 narrow, rounded, high spiral cords with a deep interspace between each pair of cords. Teleoconch of 3.5-4.2 whorls. Spiral sculpture of teleoconch whorls consisting of primary spiral cords, very rarely with additional secondary cords. Axial sculpture of numerous narrow ribs. Aperture small, width 600-900 µm × height 500-700 µm, with 4 or 5 narrow, elongate denticles within the outer lip. Operculum broadly ovate with subapical nucleus and weak inner curve on abapical left. Siphonal canal broadly open, very short, 7-10% of

total shell heigth. Radula rachiglossate with a three-dimensional rachidian bearing a central cusp with a single lateral denticle, a single marginal cusp on each side and a very small marginal cusp.

Pradoxa confirmata (Fernandes & Rolán, 1990) (Figs. 1A-D, 2A, E-F, 4A, C, G, J)

Paradoxa confirmata Fernandes & Rolán, 1990: 343, text fig. 1B, figs 4-7.

Type material examined: Holotype MNCN 15.05/1041 and several paratypes (see Rolán & Fernandes,1990)
Other material examined: São Tomé: Lagoa Azul, 4 m, MHNS, 6 lv (4 coated for SEM); Lagoa Azul, 0.5-3 m, under stones, RH, 5 lv & dd; Esprainha, 1-5 m, MHNS, 7 lv & dd; Esprainha, 2-3 m, RH, 8 dd; Minerio,10 m, MHNS,12 lv & dd; 30 m, MHNS, 5 dd; São Tomé Town, 1-3 m, MHNS, 21 lv & dd, RH, 2 lv; Sant'Ana, 0.2-3 m, brush of algae, RH, 4 lv; P. Mutamba, 6 m, MHNS, 73 dd (mostly fragments and protoconchs). Príncipe: Baía de Santo Antonio, 5 m, MHNS, 17 dd. Annobón: San Antonio de Palé, 1-8 m, MHNS, 97 dd (mainly fragments).
Type locality: São Tomé, Praia Mutamba.

Description: Shell small, up to 5 mm in height at maturity. Height/width ratio 2.6-2.7. Slender, narrowly ovate, heavy, nodose. Subsutural ramp broad, strongly sloping, weakly concave. Entirely brown, chestnut-brown or blackish brown. Inside of aperture weakly lighter coloured.

Spire very high with 2-2.1 protoconch whorls and teleoconch of up to 4-4.2 weakly convex, narrow, weakly shouldered, nodose whorls. Suture weakly adpressed. Protoconch large, broadly cylindrical, width 900 µm × height 800 µm. Whorls with 4 high, narrow, rounded spiral cords with a deep channel between each pair of cords. Each cord giving rise to a nodose spiral cord on first teleoconch whorl. Terminal lip not present.

Axial sculpture of teleoconch whorls consisting of high, narrow, rounded, nodose ribs. First whorl with 15-17 ribs, second with 17 or 18, third with 20, fourth with 20-22 ribs. Four or five last ribs of last teleoconch whorl fused, giving rise to a broad, high apertural lip. Spiral sculpture of high, strong, narrow, nodose, primary cords. First to third teleoconch whorls with SP, P1-P3, P3 occasionally partially or completely covered by next teleoconch whorl; last whorl with SP, P1-P6, ADP, (MP). SP broad, P1 and P2 of approximately similar strength and height, P3 weakly narrower and lower, P4 lowest cord, occasionally obsolete, P5 and P6 broadest and highest, similar in size, ADP narrow, MP very low and narrow or obsolete. Presence of high rounded nodes at intersection of spiral cords with axial ribs, giving a nodose appearance to the whole shell.

Aperture small, 800-900 µm high × 500 µm wide, ovate. Columellar lip narrow, smooth, occasionally with weak knob abapically. Rim completely adherent. Anal notch shallow, broad. Outer lip smooth, with 5 weak, elongate denticles within: ID, D1-D4, D4 broadest and strongest, probably D4-D5 fused. Siphonal canal very short, 7 or 8% of total shell heigth, narrow, straight, broadly open.

Operculum light brown, ovate, with subapical nucleus and weak curve on abapical left. Radula rachiglossate with a three-dimensional rachidian tooth bearing a short, broad central cusp, a narrow, long lateral denticle, a broad, long lateral cusp and a very small marginal cusp. Lateral teeth sickle-shaped with broad base.

Distribution: São Tomé, Príncipe and Annobón, living in 0.5-10 m.

Remarks: *Pradoxa confirmata* is the largest species of *Pradoxa* with specimens reaching 5 mm in height. It is easily distinguished from the other species in having a strongly nodose shell and a very high spire, a narrow shell with very weakly convex teleoconch whorls and a very low or obsolete P4 on the last teleoconch whorl. The protoconch is also different in having 4 broad spiral cords *vs* 5 or 6 in the other species.

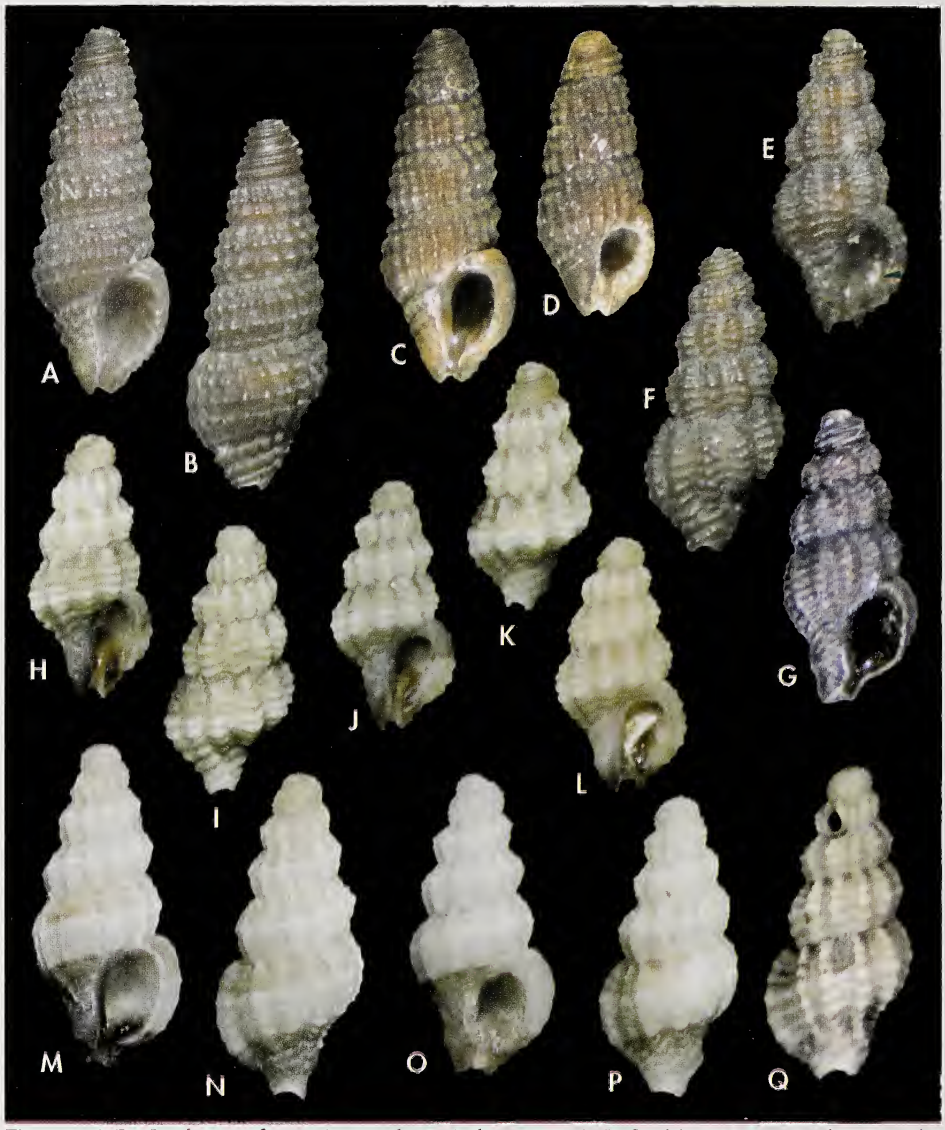


Figure 1. A-D: *Pradoxa confirmata* Fernandes & Rolán, 1990; A, B: São Tomé, Lagoa Azul, 2-3 m, 4.9 mm (MHNS); C: Lagoa Azul, 4 m, 4.1 mm (MHNS); D: San Antonio de Palé, Annobon, 3.2 mm (MHNS). E-G: *Pradoxa thomensis* Fernandes & Rolán, 1990; E, F: São Tomé, Esprainha, 1-5 m, 3.3 mm (MHNS); G: São Tomé, Lagoa Azul, 2-3 m, 2.7 mm (MHNS). H-L: *Pradoxa gorii* spec. nov. São Tomé, Minerio, 37-43 m; H, I; holotype MNHN 24260,3 mm; J, K: paratype MHNS 100559, 2.9 mm; L: paratype MHNS 100559, 2.9 mm. M-Q: *Pradoxa urdambideli* spec. nov. São Tomé, Minerio, 41 m; M, N: paratype SG , 3.6 mm; O, P: holotype MNHN 24264, 3.3 mm; Q: paratype RH, 3.7 mm.
Figura 1. A-D: Pradoxa confirmata *Fernandes & Rolán, 1990; A, B: São Tomé, Lagoa Azul, 2-3 m, 4.9 mm (MHNS); C: Lagoa Azul, 4 m, 4.1 mm (MHNS); D: San Antonio de Palé, Annobon, 3.2 mm (MHNS). E-G:* Pradoxa thomensis *Fernandes & Rolán, 1990; E, F: São Tomé, Esprainha, 1-5 m, 3.3 mm (MHNS); G: São Tomé, Lagoa Azul, 2-3 m, 2.7 mm (MHNS). H-L:* Pradoxa gorii *spec. nov. São Tomé, Minerio, 37-43 m; H, I; holotipo MNHN 24260,3 mm; J, K: paratipo MHNS 100559, 2.9 mm; L: paratipo MHNS 100559, 2.9 mm. M-Q:* Pradoxa urdambideli *spec. nov. São Tomé, Minerio, 41 m; M, N: paratipo SG , 3.6 mm; O, P: holotipo MNHN 24264, 3.3 mm; Q: paratipo RH, 3.7 mm.*

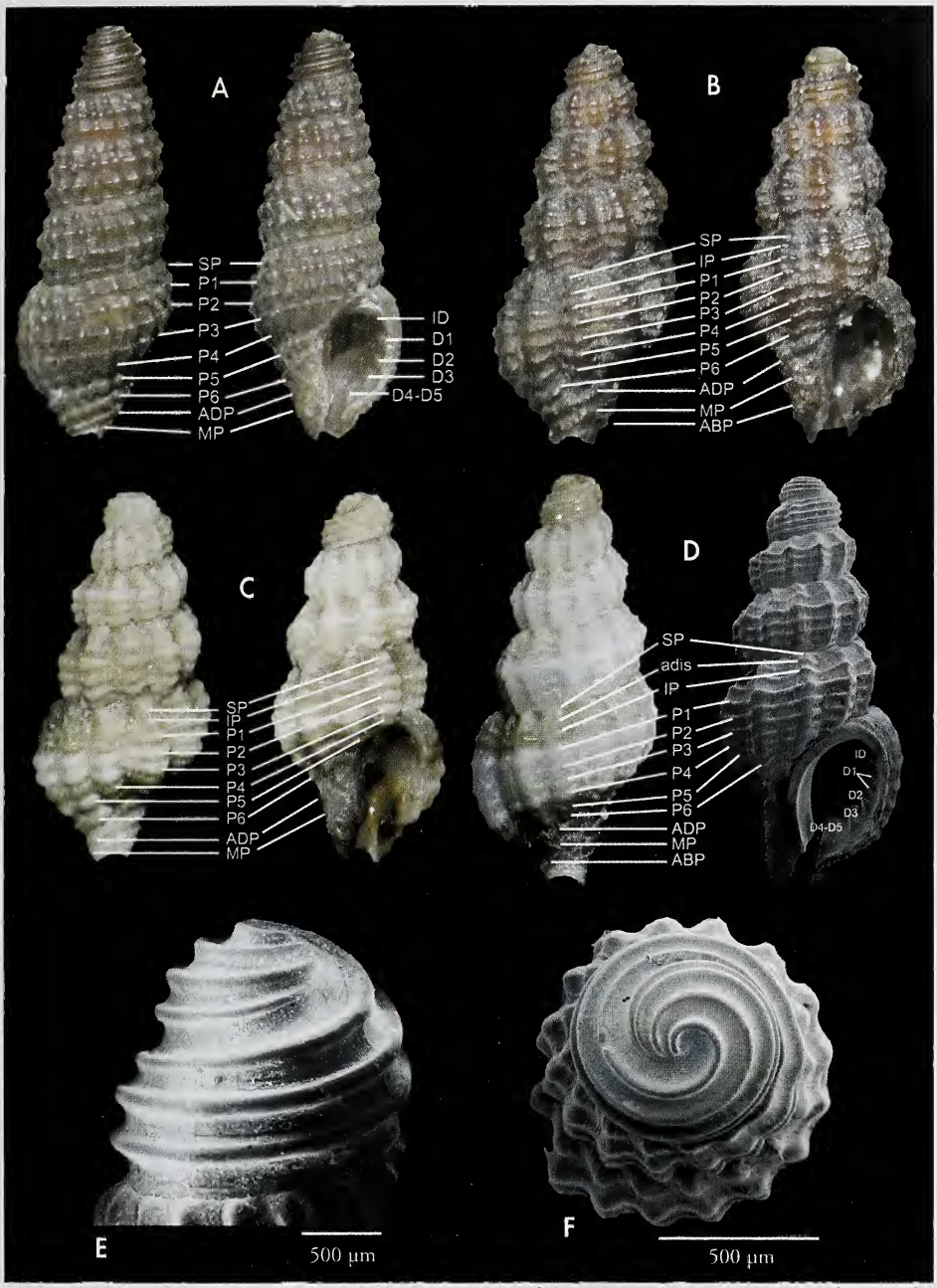


Figure 2. A-D: morphology of the spiral structure and of the apertural denticles. A: *Pradoxa confirmata* Fernandes & Rolán, 1990, São Tomé; B: *Pradoxa thomensis* Fernandes & Rolán, 1990, São Tomé; C: *Pradoxa gorii* spec. nov. São Tomé (holotype); D: *Pradoxa urdambideli* spec. nov. São Tomé. E, F: protoconch of *Pradoxa confirmata* Fernandes & Rolán, 1990.

Figura 2. A-D: mofología de la estructura espiral y dentículos de la abertura. A: Pradoxa confirmata *Fernandes & Rolán, 1990, São Tomé; B:* Pradoxa thomensis *Fernandes & Rolán, 1990, São Tomé; C:* Pradoxa gorii *spec. nov. São Tomé (holotype); D:* Pradoxa urdambideli *spec. nov. São Tomé. E, F: protoconcha of* Pradoxa confirmata *Fernandes & Rolán, 1990.*

Pradoxa thomensis (Fernandes & Rolán, 1990) (Figs. 1E-F, 2B, 3A-C, 4B, D, H, K-L)

Paradoxa thomensis Fernandes & Rolán, 1990: 345, figs 1-3.

Type material examined: Holotype MNCN 15.05/1042 and several paratypes (see Rolán & Fernandes, 1990)
Other material examined: São Tomé: Lagoa Azul, MHNS, 2 lv; Esprainha, 1-5 m, MHNS, 6 lv & dd, RH, 2 lv. Príncipe: Baía de Santo Antonio, 5 m, MHNS, 1 dd (juvenile).
Type locality: São Tomé.

Description: Shell small, up to 3.6 mm in height at maturity. Height/width ratio 2.1-2.4. Slender, lanceolate, narrowly convex, lightly built, tuberculate. Subsutural ramp narrow, weakly sloping on first teleoconch whorl, more strongly sloping on adapical whorls, weakly concave. Entirely brown or blackish brown. Inside of aperture similarly coloured.

Spire very high with 1.5-1.75 protoconch whorls and teleoconch of up to 4 broad, convex, weakly shouldered, nodose whorls. Suture weakly adpressed. Protoconch large, broad, width 600 µm × height 500 µm. Whorls rounded with 4 or 5 high, narrow, rounded spiral cords with a more or less deep channel between each pair of cords. Fifth cord usually covered or partially covered by first teleoconch whorl. Each cord giving rise to a narrow, weakly nodose spiral cord on first teleoconch whorl. Terminal lip not present.

Axial sculpture of teleoconch whorls consisting of moderately high, broad, rounded, weakly nodose ribs. First and second whorls with 10 or 11 ribs, third with 9-11, fourth with 11 ribs. Apertural rib of last teleoconch whorl 2 or 3 times broader than other ribs. Spiral sculpture of low, rounded, narrow, smooth primary cords. First and second teleoconch whorls with SP, P1-P4, P4 usually partially or completely covered by next teleoconch whorl; third whorl with SP, IP, P1-P4; last whorl with SP, IP, P1-P6, ADP, MP, (ABP). IP, P1-P4 narrow, of approximately similar size, P5 and P6 weakly broader, ADP and MP broadest; ABP when present, low and shallow. Spiral cords weakly broader and higher at intersection of spiral and axial sculpture.

Aperture small, 700-900 µm high × 500 µm wide, ovate. Columellar lip narrow, smooth, occasionally with weak, broad knob abapically. Rim completely adherent. Anal notch shallow, broad. Outer lip smooth, with 5 weak, elongate denticles within: ID, D1-D4, D4 broadest and strongest, probably D4-D5 fused. Siphonal canal very short, 6 or 7 % of total shell length, narrow, straight, broadly open.

Operculum light brown, ovate, with subapical nucleus and weak curve on abapical left. Radula rachiglossate with a three-dimensional rachidian tooth bearing a long broad central cusp, a narrow, long lateral denticle, a broad, long lateral cusp and a very small marginal cusp. Lateral teeth sickle-shaped with broad base.

Distribution: São Tomé and Príncipe, living at 1-5 m.

Remarks: *Pradoxa thomensis* differs from *P. confirmata* in being comparatively smaller and broader with more strongly convex teleoconch whorls. In having a comparatively more rounded and broader protoconch with narrow, lower spiral cords, in having less numerous axial ribs on the teleoconch whorls (9-11 vs 15-22), in having a different spiral sculpture morphology (Table II) and less obvious nodes at the intersection of spiral and axial sculpture, and in having a longer siphonal canal relative to its shell height.

Pradoxa gorii spec. nov. (Figs. 1H-L, 2C, 3D-F, 4E, I, 5A-E)

Type material: Holotype MNHN 24260. Paratypes: São Tomé, Minerio, 37-43 m - 1 IRSNB IG.31 896/ MT2540; 2 MHNS 100559;1 MNCN (catalogue number pending). Lagoa Azul, 30-35 m - 1 JCD. Lagoa Azul, 37 m - 2 RH; 5 SG; 10 PR.

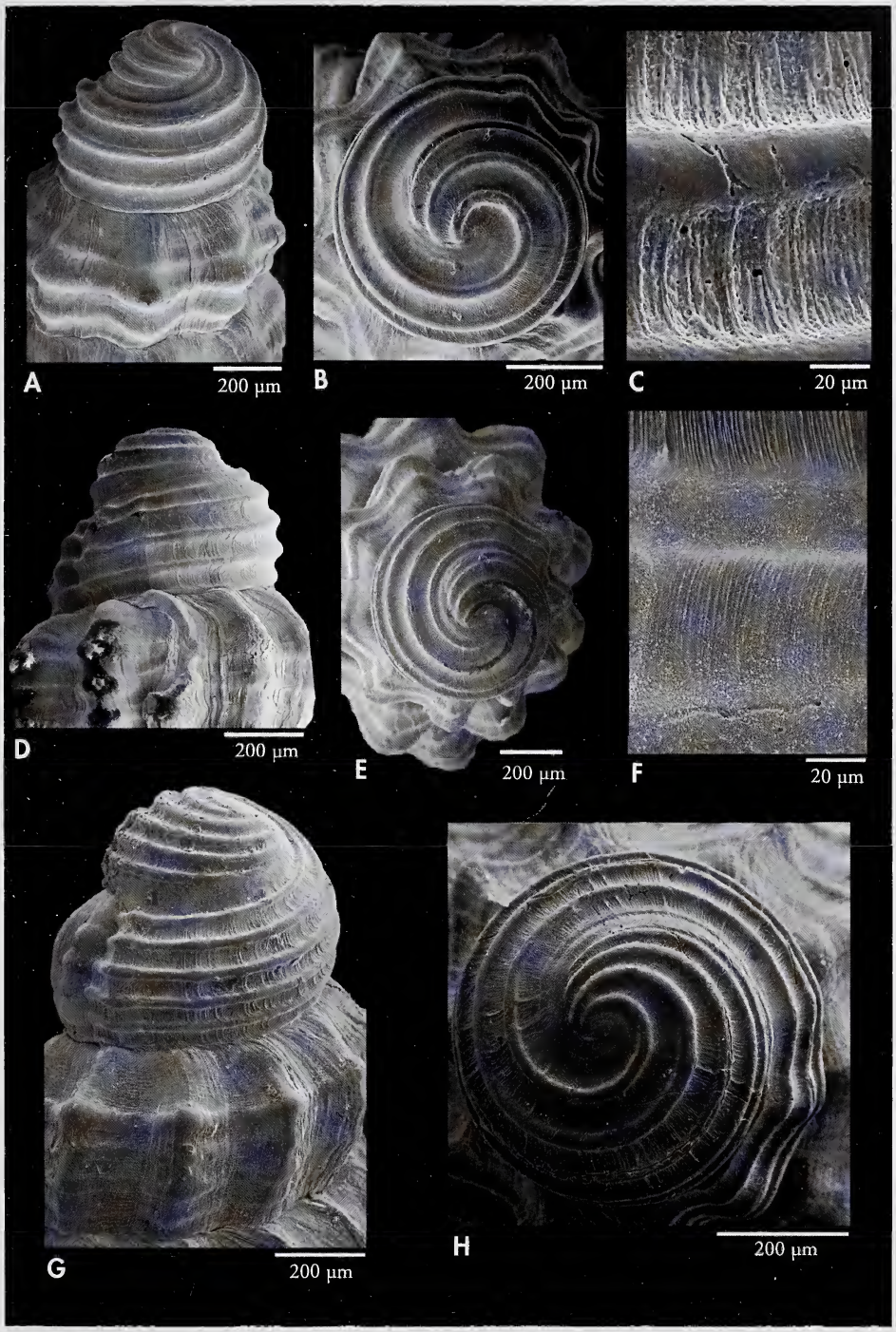


Figure 3. Protoconchs. A-C: *Pradoxa thomensis* Fernandes & Rolán, 1990, São Tomé; D-F: *Pradoxa gorii* spec. nov. São Tomé; G, H: *Pradoxa urdambideli* spec. nov. São Tomé.
Figura 3. Protoconchas. A-C: Pradoxa thomensis *Fernandes & Rolán, 1990, São Tomé; D-F:* Pradoxa gorii *spec. nov. São Tomé; G, H:* Pradoxa urdambideli *spec. nov. São Tomé.*

Other material examined: São Tomé: Lagoa Azul, 37 m, 41 lv, SG; Lagoa Azul, 30-35 m, 13 dd, RH; 9 lv & dd, MHNS; Minerio, 41 m, 9 lv, SG; Minerio, 37-43 m. 9 lv & dd, RH; 7 dd (fragments), MHNS.
Etymology: We are very pleased to name this new species in honour of our mutual friend Sandro Gori (Livorno, Italy), who provided us with the material studied herein.
Type locality: São Tomé, Minerio, 37-43 m.

Description: Shell small, up to 3.5 mm in height at maturity. Height/width ratio 1.9-2.2. Lanceolate, narrowly convex, tuberculate. Subsutural ramp broad, strongly sloping, almost straight or weakly convex. Creamy white or light tan with darker coloured band on subsutural ramp, on abapical part of last teleoconch whorl and on tip of siphonal canal, P2 and P3 creamy white. Protoconch occasionally slightly darker, Aperture creamy white or light tan with brown band adapically and abapically on columellar lip and inside of aperture. D4 darker brown.

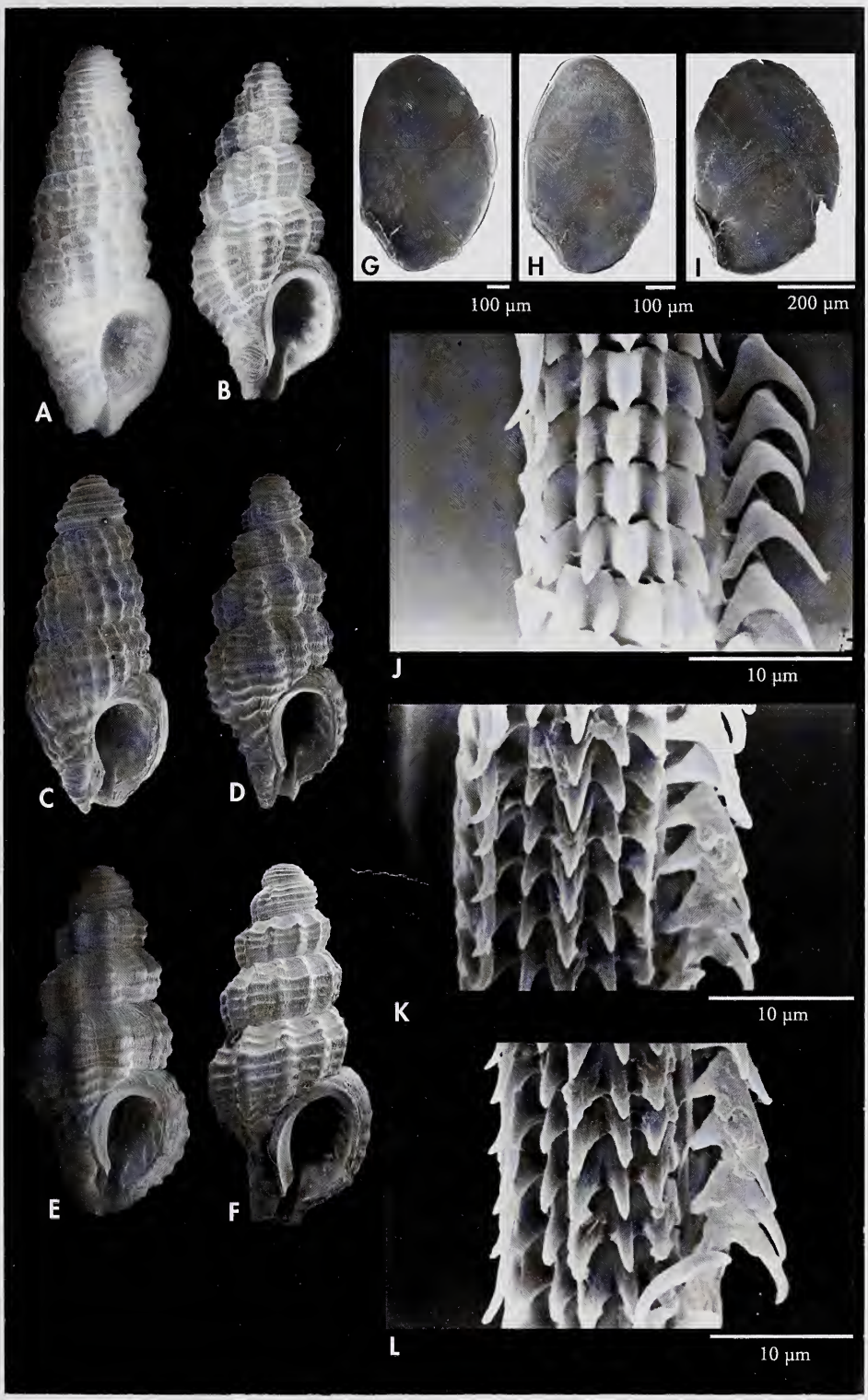
Spire high with 1.5-1.75 protoconch whorls and teleoconch of up to 3.5 broad, convex, weakly shouldered, nodose whorls. Suture weakly adpressed. Protoconch large, broad, width 600 µm × height 400-500 µm. Whorls rounded with 5 high, narrow, rounded spiral cords with a more or less deep channel between each pair of cords. Last adapical cord narrower. Each cord giving rise to a narrow, nodose spiral cord on first teleoconch whorl. Terminal lip not apparent.

Axial sculpture of teleoconch whorls consisting of high, broad, rounded, nodose ribs. First whorl with 10-12 ribs, second with 9-11 ribs, last whorl with 10 or 11 ribs. Apertural rib of last teleoconch whorl twice as broad as other ribs. Spiral sculpture of high, rounded, strong, broad, smooth, primary cords. First and second teleoconch whorls with SP, IP, P1-P3; third and last whorls with SP, IP, P1-P6, ADP, MP, (ABP). IP, P1 narrow, P2 and P3 broadest cords, P4, P5, P6, ADP broad, of similar size, MP and ABP narrow when present. Spiral cords weakly broader and higher at intersection of spiral and axial sculpture.

Aperture small, 600-700 µm high × 500 µm wide, broadly ovate. Columellar lip narrow, smooth, with single, strong, broad knob abapically. Rim completely adherent. Anal notch shallow, broad. Outer lip smooth, with 4 weak, elongate denticles within: D1-D4, D4 broadest and strongest, probably D4-D5 fused. Siphonal canal very short, 7-10 % of total shell height, narrow, straight, broadly open.

Operculum colourless, translucent, ovate, with subapical nucleus and weak curve on abapical left. Radula rachiglossate with a three-dimensional rachidian

(Right page) Figure 4. A: *Pradoxa confirmata* Fernandes & Rolán, 1990, São Tomé, holotype MNCN 15.05/1041, 4.3 mm. B: *Pradoxa thomensis* Fernandes & Rolán, 1990, São Tomé, holotype MNCN 15.05/1042, 3.4 mm. C-F: Coated SEM; C: *Pradoxa confirmata* Fernandes & Rolán, 1990, São Tomé, 3.5 mm; D: *Pradoxa thomensis* Fernandes & Rolán, 1990, 2.9 mm; E: *Pradoxa gorii* spec. nov. São Tomé, 3.1 mm; F: *Pradoxa urdambideli* spec. nov. São Tomé, 3.4 mm. G-I: opercula; G: *Pradoxa confirmata* Fernandes & Rolán, 1990 (SEM A. Warén); H: *Pradoxa thomensis* Fernandes & Rolán, 1990 (SEM A. Warén); I: *Pradoxa gorii* spec. nov. J-L: radulae; J: *Pradoxa confirmata* Fernandes & Rolán, 1990 (SEM A. Warén); K-L: *Pradoxa thomensis* Fernandes & Rolán, 1990 (SEM A. Warén).
(Página derecha) Figure 4. A: Pradoxa confirmata *Fernandes & Rolán, 1990, São Tomé, holotype MNCN 15.05/1041, 4.3 mm. B:* Pradoxa thomensis *Fernandes & Rolán, 1990, São Tomé, holotype MNCN 15.05/1042, 3.4 mm. C-F: Coated SEM; C:* Pradoxa confirmata *Fernandes & Rolán, 1990, São Tomé, 3.5 mm; D:* Pradoxa thomensis *Fernandes & Rolán, 1990, 2.9 mm; E:* Pradoxa gorii *spec. nov. São Tomé, 3.1 mm; F:* Pradoxa urdambideli *spec. nov. São Tomé, 3.4 mm. G-I: opercula; G:* Pradoxa confirmata *Fernandes & Rolán, 1990 (SEM A. Warén); H:* Pradoxa thomensis *Fernandes & Rolán, 1990 (SEM A. Warén); I:* Pradoxa gorii *spec. nov. J-L: radulae; J:* Pradoxa confirmata *Fernandes & Rolán, 1990 (SEM A. Warén); K-L:* Pradoxa thomensis *Fernandes & Rolán, 1990 (SEM A. Warén).*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tooth bearing a long broad central cusp, a narrow, long lateral denticle, a broad, long lateral cusp and a very small marginal cusp. Lateral teeth sickle-shaped with broad base.

Distribution: São Tomé, living at 30-47 m.

Remarks: *Pradoxa gorii* spec. nov. differs in many ways from *P. confirmata* (Figs. 1A-D) and does not need to be compared here with this species.

Pradoxa gorii spec. nov. differs from *P. thomensis* (Figs. 1E-G) in having a more strongly shouldered shell with lower teleoconch whorls, a broader, weakly convex and less sloping subsutural ramp, comparatively broader axial ribs, broader and more closely set spiral cords with a different morphology, a more obvious apertural D4, and a different microsculpture of the protoconch (Fig. 3) In all the populations there is an axial striation between the spiral cords of the protoconch; this is more irregular in *P. thomensis* (Fig. 3C) and more regular in *P. gorii* spec. nov. (Fig. 3F).

Pradoxa gorii spec. nov. also has a different shell colour, the shell of *P. thomensis* being uniformly dark brown (see also Table II).

Pradoxa urdambideli spec. nov. (Figs. 1M-Q, 2D, 3G-H, 4F)

Type material: Holotype MNHN 24264. Paratypes: São Tomé, Minerio, 41 m - 2 MHNS 100560; 2 RH; 1 SG; 1 PR (lv & dd).
Etymology: The species is named after Carlos Urdambidelus, physitian and recognized researcher in genealogy, friend and family of the junior author.
Type locality: São Tomé, Minerio, 41 m.

Description: Shell small, up to 3.8 mm in height at maturity. Height/width ratio 2.0-2.2. Lanceolate, narrowly convex. Subsutural ramp broad, weakly sloping, weakly convex. White or light creamy white with a light tan or light brown band on abapical part of last teleoconch whorl, covering P5, P6, ADP, MP and ABP, and an occasional additional very lightly coloured spiral band on subsutural area. Aperture white within, apertural denticle D4, columellar lip and occasionally inside of outer lip dark brown.

Spire very high with 1.5-1.75 protoconch whorls and teleoconch of up to 4 broad, convex, weakly or strongly shouldered, lightly nodose whorls. Suture weakly adpressed. Protoconch large, broad, width 600-700 µm × height 500-600 µm. Whorls rounded with 6 narrow, rounded, moderately high spiral cords with a moderately deep channel between each pair of cords. Sixth cord (adapical) occasionally covered by first teleoconch whorl. Each cord giving rise to a narrow nodose spiral cord on first teleoconch whorl. Terminal lip not apparent.

Axial sculpture of teleoconch whorls consisting of moderately high, broad, rounded ribs. First whorl with 10-12 ribs, second with 10 or 11 ribs, third with 10-12 ribs, last whorl with 11 ribs. Apertural rib of last teleoconch whorl two or three times broader and quite higher than other ribs. Spiral sculpture of low, rounded, narrow, smooth, primary and secondary cords. First and second teleoconch whorls with SP, IP, P1-P4, P4 occasionally covered by next whorl; third whorl with SP, (adis), IP, P1-P4 or P1-P5, last whorl with SP, adis, IP, P1-P6, ADP, MP, (ABP). Primary cords of similar size, P1 occasionally weakly broader and higher. Spiral cords very weakly broader and higher at intersection of spiral and axial sculpture.

Aperture small, 800-900 µm high × 600-700 µm wide, broadly ovate. Columellar lip narrow, smooth, with occasional, single, weak knob abapically. Rim partially weakly erect abapically, adherent adapically. Anal notch shallow, broad. Outer lip smooth, with 5 weak, elongate denticles within: ID, D1-D4, D4 broadest and strongest, probably D4-D5 fused, D1 rarely split. Siphonal canal

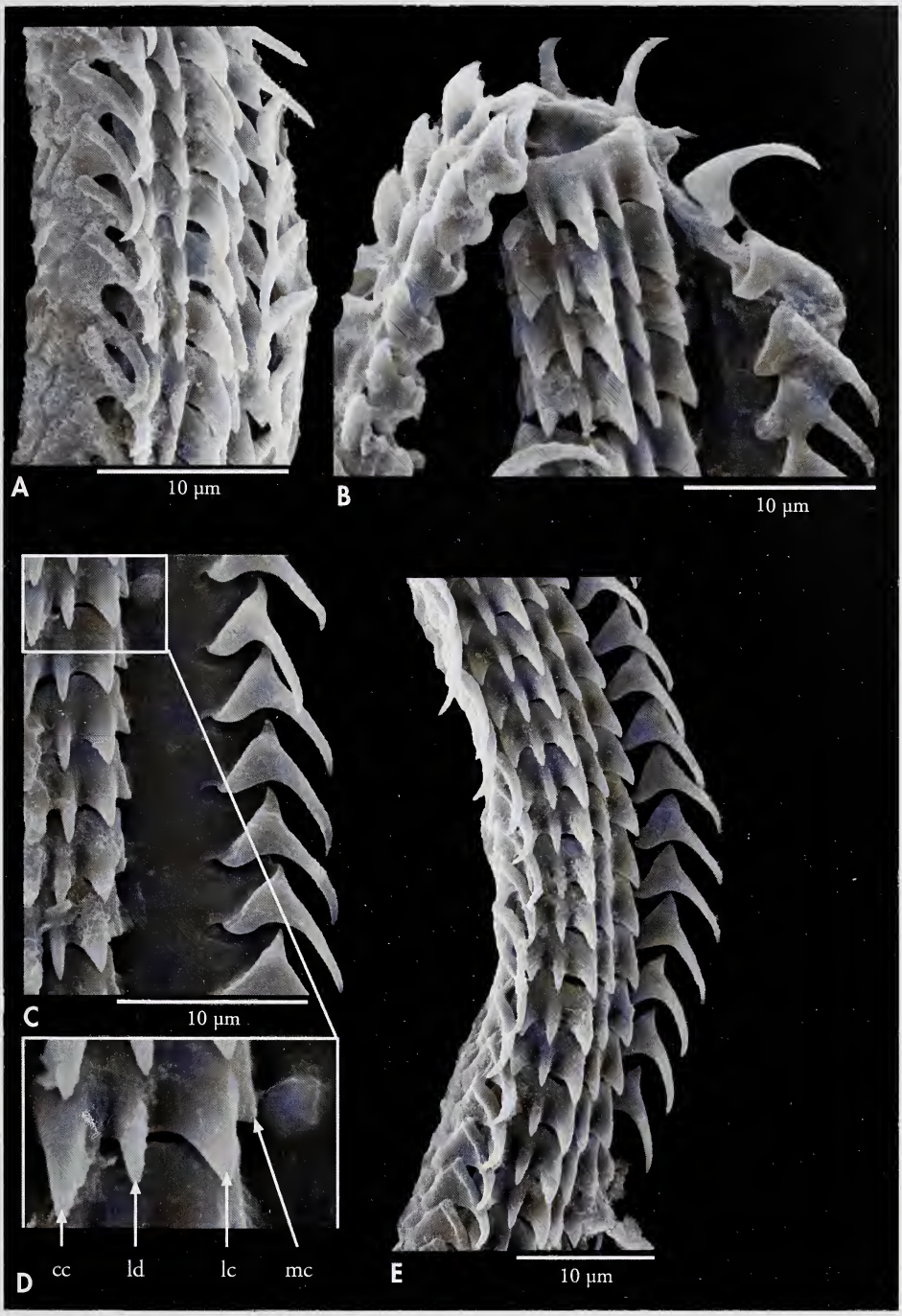

Figure 5. A-E: radular morphology of *Pradoxa gorii* spec. nov. Radula characters (rachidian tooth): cc= central cusp, ld= lateral denticle, lc= lateral cusp, mc= marginal cusp (Figure 5D).

Figura 5. A-E: morfología radular de Pradoxa gorii *spec. nov. Caracteres de la rádula (diente raquídeo): cc= cúspide central, ld= dentículo lateral, lc= cúspide lateral, mc= cúspide marginal (Figura 5D).*

Table II. Comparison of the shell morphology in the *Pradoxa* species.
Tabla II. Comparación de la morfología de la concha de las especies de Pradoxa.

Character	*Pradoxa confirmata*	*Pradoxa thomensis*	*Pradoxa gorii* spec. nov.	*Pradoxa urdambideli* spec. nov.
Maximum height	5 mm	3.6 mm	3.5 mm	3.8 mm
Height/width ratio	2.6-2.7	2.1-2.4	1.9-2.2	2.0-2.2
Width and height of protoconch	900 × 800 µm	600 × 500 µm	600 × 400-500 µm	600-700 × 500-600 µm
Sculpture of protoconch	4 high, narrow, rounded spiral cords	4 or 5 high, narrow, rounded spiral cords	5 high, narrow, rounded spiral cords	6 narrow, rounded, moderately high spiral cords
Number of axial ribs on last teleoconch whorl	20-22	11	10 or 11	11
Spiral cords on last teleoconch whorl	SP, P1-P6, ADP, (MP)	SP, P1-P6, ADP, MP, (ABP)	SP, IP, P1-P6, ADP, MP, (ABP)	SP, adis, IP, P1-P6, ADP, MP, (ABP)
Morphology of spiral cords	SP broad, P1 and P2 of approximately similar strength and height, P3 weakly narrower and lower, P4 lowest cord, occasionally obsolete, P5 and P6 broadest and highest, similar in size, ADP narrow, MP very low and narrow or obsolete	IP, P1-P4 narrow, of approximately similar size, P5 and P6 weakly broader, ADP and MP broadest; ABP when present, low and shallow	IP, P1 narrow, P2 and P3 broadest cords, P4, P5, P6, ADP broad, of similar size, MP and ABP narrow when present	Primary cords of similar size, P1 occasionally weakly broader and higher
Aperture height and width	800-900 × 500 µm	700-900 × 500 µm	600-700 × 500 µm	800-900 × 600-700 µm
Length of the siphonal canal	7 or 8% of total shell length	6 or 7 % of total shell length	7-10 % of total shell length	8-9% of total shell length
Colour	Entirely brown, chestnut-brown or blackish brown. Inside of aperture slightly lighter	Entirely brown or blackish brown. Inside of aperture similarly coloured	Creamy white or light tan with darker band on subsutural ramp, on abapical part of last teleoconch whorl and on tip of siphonal canal, P2 and P3 creamy white. Protoconch occasionally slightly darker, Aperture creamy white or light tan with brown band adapically and abapically on columellar lip and inside of aperture. D4 darker brown	White or light creamy white with a light tan or light brown band on abapical part of last teleoconch whorl covering P5, P6, ADP, MP and ABP, and an occasional additional very lightly coloured spiral band on subsutural area. Aperture white within, apertural denticle D4 and occasionally inside of outer lip dark brown

very short, 8-9 % of total shell height, narrow, straight, broadly open.

Operculum and radula unknown.

Distribution: Only known from the type locality.

Remarks: *Pradoxa urdambideli* spec. nov. differs from *P. gorii* spec. nov. (Figs. 1H-L) in having a larger shell with the same number of teleoconch whorls, in having a comparatively broader and larger aperture, weakly higher and less shouldered teleoconch whorls, especially the last whorl, and in having comparatively narrower spiral cords, more widely spaced from each other and of approximately similar size *vs* more variable in *P. gorii* spec. nov. (see Table II), in the presence of adis, not observed in *P. gorii* spec. nov. (Fig. 2D) and in having a protoconch with 5 or 6 spiral cords, instead of 4, rarely 5 in *P. gorii* spec. nov. (Figs. 3D-H)

Pradoxa urdambideli spec. nov. differs from *P. thomensis* (Figs. 1E-G) in having more strongly shouldered teleoconch whorls, a comparatively broader protoconch, a broader aperture, narrower axial ribs, a protoconch with 5 or 6 narrow spiral cords on the last whorl instead of 4 in *P. thomensis*, in the presence of the secondary cord adis on penultimate and last teleoconch whorls and, as in *P. gorii*, in having a different shell colour. Apparently, *P. urdambideli* is also the only species with a lightly abapically erect columellar lip while completely adherent in the three other species. See also Table II.

DISCUSSION

There are still strong doubts about the correct subfamilial placement of this genus.

We consider that the following differences are very important and significant characters which differentiate *Pradoxa* from the other genera in Muricopsinae and from other subfamilies as well:

- an almost cylindrical, very small shell with a very high spire;
- a very short siphonal canal and a very small aperture *vs* a very large and broad protoconch;
- an operculum with a weak curve on abapical left (Figs. 4G-I);
- the form, the peculiar sculpture and the large size of the protoconch.

Unfortunately the DNA study of *Pradoxa* did not give any information to date. Further attempts will be made with new material soon. We will follow the next steps very closely and will publish the results of these investigations and their conclusions.

ACKNOWLEDGEMENTS

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A taxonomic revision of *Oestophora barbula* (Rossmässler, 1838) and *O. barbella* (Servain, 1880), two Iberian endemic land-snail species (Gastropoda: Trissexodontidae)

Revisión taxonómica de *Oestophora barbula* (Rossmässler, 1838) y *O. barbella* (Servain, 1880), dos especies de caracoles terrestres endémicas de la península ibérica (Gastropoda: Trissexodontidae)

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ABSTRACT

Oestophora barbula and *O. barbella* are distinct biological species that can be reliably distinguished only by the longer and stouter penial epiphallus of the former taxon. *Oestophora barbula* is endemic in western-central Portugal, whereas *O. barbella* has a much larger range in western Iberia, including parts of the area occupied by *O. barbula*. Most populations of *O. barbula* have strongly keeled shells and they live mainly in habitats with exposed (Mesozoic) limestone rock. *Oestophora barbella* has the shell periphery rounded to moderately keeled, a small minority of its shells being indistinguishable from some of *O. barbula*. *Oestophora barbella* is found in varied habitats disturbed by man and in more natural situations, some of which have very acidic or strongly basic rocks. It occurs in rocky (Mesozoic) limestone habitats in the Algarve and Serra da Arrábida, but is usually replaced by *O. barbula* in similar habitats over much of western-central Portugal. The two species have been found living together only at one locality in the Serra da Arrábida, where they differ widely in shell size. Type material of both species has been located and lectotypes are designated here.

RESUMEN

Oestophora barbula y *O. barbella* son especies biológicas diferentes, que pueden distinguirse sólo por el epifalo más largo y más grueso del primer taxón. *Oestophora barbula* es un endemismo del oeste y centro de Portugal, mientras que *O. barbella* tiene una distribución mucho más extensa en el oeste de la Península Ibérica, incluyendo partes del área ocupada por *O. barbula*. La mayoría de las poblaciones de *O. barbula* tienen conchas con una fuerte quilla y viven en hábitats expuestos de roca caliza (Mesozoico). *Oestophora barbella* tiene la periferia de la concha redondeada o con una quilla moderada, aunque una pequeña minoría de sus conchas fuera indistinguible de algunos *O. barbula*. *Oestophora barbella* se encuentra en distintos hábitats alterados por el hombre y también en otros más naturales, algunos de ellos con rocas muy ácidas o ultrabásicas. Se encuentra en hábitats de roca caliza (Mesozoico) en el Algarve y la Serra da Arrábida, pero suele estar reemplazado por *O. barbula* en este tipo de hábitats en la mayor parte del oeste y centro de Portugal. Las dos especies se han encontrado simpátricas sólo en una localidad de la Serra da Arrábida, en donde difieren ampliamente en el tamaño de la concha. El material tipo de ambas especies ha sido localizado y se designan aquí lectotipos.

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INTRODUCTION

Oestophora barbula is currently regarded as a widespread and often common land snail throughout the western half of the Iberian Peninsula, readily distinguished from other species of the genus by the usual presence of two palatal teeth in the shell mouth (Puente, 1996). Although its local populations vary considerably in shell size and development of a peripheral keel, variation in the genital anatomy has been regarded as rather slight and taxonomically unimportant in most of the recent literature. Castillejo, Outeiro and Rodríguez (1987) reported some differences in the distal genitalia and in development of a shell keel within coexisting populations in the Serra da Estrela of eastern Portugal, leading them to argue that *O. barbula* was coexisting with *O. barbella* at those localities. However, we agree with Puente (1996) that the rather small differences in genital anatomy demonstrated in that study can be attributed to individual variation within a single species.

The first detailed description of the genital anatomy of *O. barbula* by Hesse (1931) nevertheless reported different genital anatomy to that described and figured by almost all subsequent authors (cf. Ortiz de Zárate Lopez, 1962; Manga, 1983; Castillejo, 1984; Castillejo *et al.*, 1987; Puente, 1996), with a much longer and thicker penial epiphallus. Ortiz de Zárate López (1962) attributed this difference to the epiphallus in Hesse's material being swollen due to the supposed presence of a spermatophore inside, a suggestion later cited by Puente (1996). However, this seems unlikely as the shape of the spermatophore in Helicacea is determined by the internal shape of the epiphallus in which it forms, rather than *vice-versa*. Hesse dissected three individuals from near Lisbon and he presented three drawings (Hesse, 1931: Taf. 8, Figs. 63A-C) each showing similar anatomy with a large epiphallus, so it anyway seems unlikely that all three should have the epiphallus similarly distended by a spermatophore which Hesse did not notice.

The present paper reports a study of *Oestophora barbula sensu lato* from Portugal and neighbouring regions of Spain. It soon became apparent that many populations from western-central Portugal show the large epiphallus figured by Hesse and these were mainly also characterised by strongly keeled shells. Rossmässler's type material of *O. barbula* appears to be of this localised endemic form. All other populations studied resembled Spanish material in having a smaller epiphallus and they almost always lacked a really strong keel on the shell; the oldest valid name applicable to this form is *O. barbella* (Servain, 1880). Lectotypes are designated here for both names. The two taxa live close together in parts of western Portugal and living populations of both with no intermediates were collected from beneath the same boulders at one locality in the Serra da Arrábida. We also discuss variability in shell morphology and problems of species identification from shells, and apparent differences in the range of habitat preferences of each species.

MATERIAL AND METHODS

Field collections by the authors consisted of all mature shells found, to avoid possible bias in favour of large specimens. Localities and altitudes were recorded mainly using a Garmin Etrex High Sensitivity hand-held GPS, accurate to within 10 metres. From 2007 onwards sites were given consecutive serial numbers (e.g. P37). Habitat notes (including bedrock type and vegetation) and associated Mollusca were also recorded at all sites. Adult snails could readily be recognised by the thickened, reflected lip to the shell mouth and these normally had enlarged distal genitalia. Living adult specimens collected by the authors for anatomical study were drowned by immersion in water overnight, transferred to 80% Industrial Methylated Spirit, then pulled or part-

pulled from the shell when the body hardened after a few days. "Proximal" and "distal" refer to the position in relation to the ovotestis. Drawings of the distal genital anatomy were prepared using a Meiji drawing tube on a Meiji RZ series stereomicroscope.

Measurements of shell breadth and height, and counts of whorls followed the methods described by KERNEY AND CAMERON (1979). These shell measurements were made on adult shells to the nearest 0.1 mm using an eye-piece graticule in a stereo-microscope. Accuracy of the counts of whorls was slightly reduced by the protoconch often appearing somewhat triangular when viewed from above, rather than semicircular. Measurements of (greatest) width of umbilicus and the breadth of the same shell were measured using Infinity Analyze© software on images of adult shells taken with an Infinity 1 camera on a Meiji RZ series stereomicroscope. The measurements on the images were reproducible to ± < 0.01 mm, but unavoidable slight tilting of the shells almost certainly caused some additional loss of precision.

Full details of specimens studied by the authors are listed in the Appendix, which includes all those used for anatomical study. In addition notes on shells in the Coimbra, Lisbon and Porto Museums were kindly supplied by Álvaro De Oliveira, along with specimens and data from his personal collection; this information has been added to the distribution maps. Two syntypes of *O. barbula* were studied from high quality photographs supplied by the Forschungsinstitut Senckenberg. 12 syntypes of *O. barbella* were studied on loan from the Bourguignat Collection housed at the Muséum d'Histoire Naturelle, Ville de Genève. The remainder of the material studied is retained in the Collection of G.A. and D.T. Holyoak.

RESULTS AND DISCUSSION

Genital anatomy. The genital anatomy of *O. barbella* from Spain was carefully and accurately described by PUENTE (1996) under the name *O. barbula* with clear drawings of nine individuals. Hence the present account concentrates on the differences between *O. barbella* and *O. barbula*, which appear to be confined to the distal genitalia, especially the epiphallus and penis (Figs. 1-2).

In the present study, distal genitalia have been dissected and described in detail from 142 individual snails representing 66 populations (listed in Appendix). *O. barbula* was represented by 35 individuals (+ 1 with genitalia too immature to be useful), representing 16 populations; *O. barbella* was represented by 102 individuals (+ 4 with genitalia too immature to be useful), representing 49 populations. Only one population (7 individuals, from site P67/P161) could not be securely assigned to either taxon on the basis of the epiphallus; the identity of this unusual population is discussed below.

Figures 1-2 give representative drawings of the penis and epiphallus in varied individuals of each species. Table I compares measured proportions of epiphallus length relative to penis length and thickness of epiphallus compared to thickness of penis. In mature individuals, the epiphallus length is generally less than half the penis length in *O. barbella*, more than half the penis length in *O. barbula*. The thickness of the epiphallus is generally less than that of most of the penis (the epiphallus appearing thin-walled) in *O. barbella*, equal to or more than that of most of the penis (and appearing muscular and thick-walled) in *O. barbula*. Combining the length and thickness criteria left very few individual snails that were difficult to assign to one species or the other. Study of the internal structures of penis and epiphallus of a few individuals did not reveal any clear interspecific differences.

A single population (P67/P161: *ca* 2.3 km NE. of São Pedro de Moel, Estremadura) remained problematical with seemingly intermediate epiphallus characteristics based on seven mature specimens (epiphallus relatively long but usually no stouter than penis: Fig. 2G). On the basis of the epiphallus length

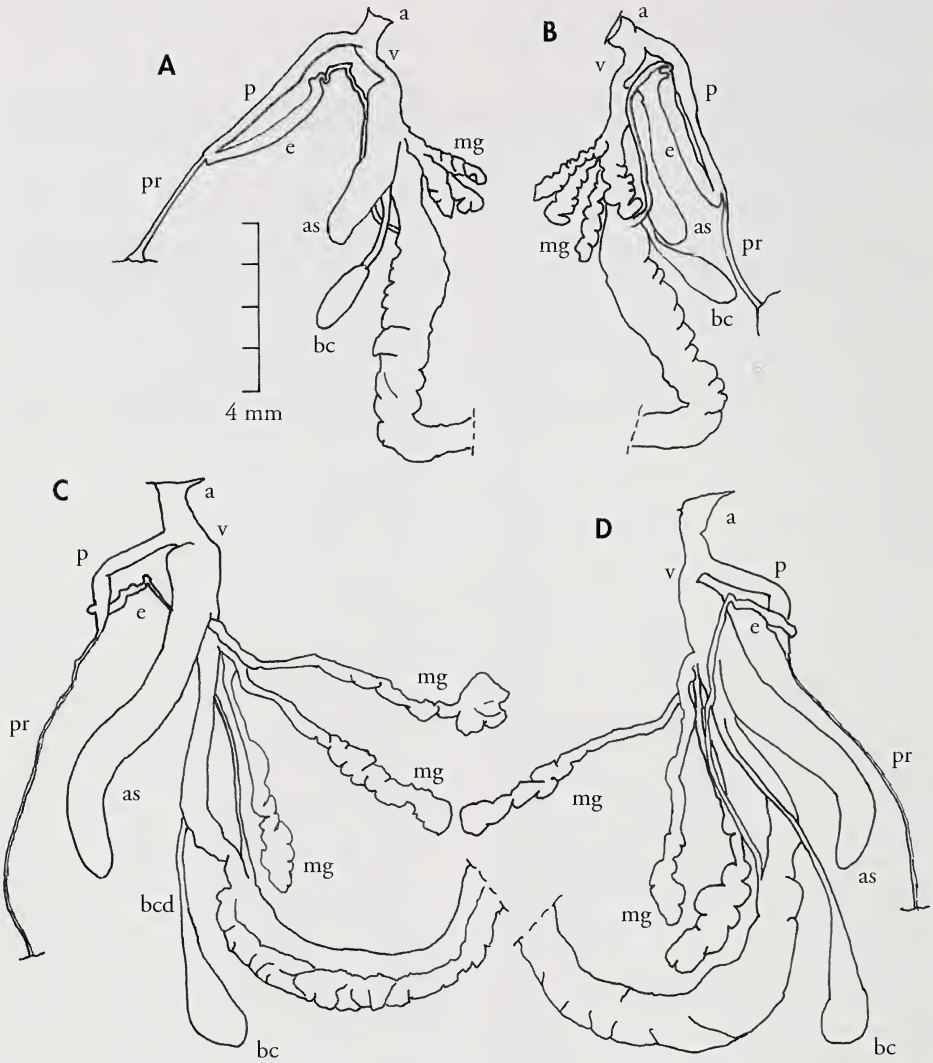

Figure 1. Anatomy of distal genitalia in representative specimens of *Oestophora* from Portugal. A: *O. barbula* (Rossmässler, 1838), 2 May 2010, SE. of Moitas Venda, Ribatejo (slightly atypical specimen with four mucus glands); B: same specimen viewed from opposite side; C: *O. barbella* (Servain, 1880), 3 Nov. 2010, NW. of Verride near Rio Mondego, Beira Litoral; D: same specimen viewed from opposite side (specimens in collection of G.A. and D.T. Holyoak). Abbreviations, a: atrium; as: accessory sac on vagina (with small dart sac at distal end); bc: bursa copulatrix; bcd: bursa copulatrix duct; e: epiphallus; mg: mucus gland; p: penis; pr: penis retractor; v: vagina; vd: vas deferens.

Figura 1. Anatomía de los genitales distales en ejemplares representativos de Oestophora *de Portugal. A:* O. barbula *(Rossmässler, 1838), 2 may. 2010, SE. de Moitas Venda, Ribatejo (ejemplar un poco atípico, con cuatro glándulas mucosas); B: mismo ejemplar visto desde el lado opuesto; C:* O. barbella *(Servain, 1880), 3 nov. 2010, NW. de Verride cerca de Río Mondego, Beira Litoral; D: mismo ejemplar visto desde el lado opuesto (ejemplares en la colección de G.A. y D.T. Holyoak). Abreviaturas, a: atrio; as: saco accesorio en la vagina (con pequeño saco del dardo en el extremo distal); bc: bursa copulatrix; bcd: conducto de la bursa copulatrix; e: epifalo; mg: glándula mucosa; p: pene; pr: retractor del pene; v: vagina; vd: vaso deferente.*

Table I. Relative size of epiphallus and penis in *Oestophora barbula* and *O. barbella*. Data are given only for individuals with distal genitalia sufficiently large to be regarded as mature or close to maturity. N = number of individuals.
Tabla I. Tamaño relativo del epifalo y del pene en Oestophora barbula *y* O. barbella. *Los datos se dan sólo para los individuos con genitales distales suficientemente grandes como para ser considerados maduros o cerca de la madurez. N = número de individuos.*

Epiphallus length/penis length		0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
O. barbula	N	-	-	-	-	2	2	4	5	14	4	1	1	-	1	1
O. barbella	N	21	58	14	6	2*	1†	-	-	-	-	-	-	-	-	-
P67/161: S. Pedro de Moel	N	-	-	-	1	2	3	-	1	-	-	-	-	-	-	-

* = 1 of these deformed,
† = with abnormally short penis

Epiphallus thickness: penis thickness		thinner	± equal	thicker
O. barbula	N	-	3	32
O. barbella	N	95	6	1
P67: S. Pedro de Moel	N	-	6	1

they were certainly closer to *O. barbula*, but the small, unkeeled shells (Table II, Figs. 4G-I) were superficially much more similar to those of some *O. barbella*. However, the proportionately very small umbilicus is much more like that of *O. barbula* than of populations of *O. barbella* from western-central Portugal (cf. Table III, Figs. 3, 4 and notes below). Nevertheless, the habitat was more like that of other material confirmed as *O. barbella* (among limestone boulders used to construct the abutment of a small bridge over a stream in a coastal region with unconsolidated Quaternary sands supporting a tall *Eucalyptus* plantation; see below for additional information). The possibility that this population represents an undescribed third species seems unlikely in view of its lack of any unique characters, the single locality and the disturbed habitat. Hence it is tentatively regarded here as a population of *O. barbula* with shells that lack a keel and show a relatively narrow umbilicus, although further study is needed in view of the relatively weak epiphallus and habitat atypical for that species (see below).

The functional explanation of the longer, thicker epiphallus of *O. barbula* compared to that of *O. barbella* is uncertain. It is noteworthy that the epiphallus is approximately similar in length to the bursa copulatrix duct in *O. barbula* (ratio *ca* 1:1, Figs. 1A, B), whereas the epiphallus is much shorter and the bursa copulatrix duct much longer in *O. barbella* (ratio *ca* 1:3, Figs. 1C, D). Hence, it might be surmised that if a spermatophore is formed inside the epiphallus as usual in many (if not all) species of Helicacea, it will be longer in *O. barbula* than in *O. barbella*. Indeed, the epiphallus in *O. barbella* is so short in comparison to its bursa copulatrix duct that a spermatophore formed inside it would apparently be too short for effective fertilisation in the manner described for *Helix pomatia* L. by LIND (1973) and currently assumed to be widespread in Helicacea. This fertilisation mechanism involves the spermatophore lodging inside the bursa copulatrix duct, so that when some of the spermatozoa it contains escape through its tail canal they reach the spermatheca by way of the oviduct. Corresponding to this widely accepted model of the fertilisation process, KOENE AND SCHULENBERG (2005) found correlations between the length of the penial flagellum and the spermatophore-receiving organ in helicoid land

snails in general, indicating coevolution which probably results from counter-adaptation between male and female reproductive organs that may control fertilisation. Likewise, Sauer and Hausdorf (2009) demonstrated a positive scaling between male spermatophore producing organs and female spermatophore-receiving organs in *Xerocrassa* species (Hygromiidae *sensu lato*) from Crete, indicating sexual coevolution which they attributed to sexual selection processes. The relative lengths of epiphallus and bursa copulatrix duct in *O. barbula* and *O. barbella* differ so markedly from results of these studies that further study is needed. Spermatophores have apparently not been described in the literature for *Oestophora* and they were not noticed during the present study. Hence, it should be established whether the spermatozoa are transferred in spermatophores in both species, and whether or not self-fertilisation is common. Mating was seen only once during our fieldwork, a pair of *O. barbella* in coitus being collected on 3 November 2010, at *ca* 11.00 hours, on the undersurface of a limestone boulder, 1 km NW. of Verride near the Rio Mondego, Beira Litoral.

Seixas (1976) gave a confused account of a Portuguese *Oestophora* under the name "*Mastigophalus rangi* (De Férussac) Deshayes, 1839", concluding that *Oestophora lusitanica* (L. Pfeiffer, 1841) may be the same species as that correctly known as *Mastigophallus rangianus* (Férussac, 1822). The latter is

(Right page) Figure 2. Distal male genitalia in representative specimens of *Oestophora* from Portugal. A-F: *O. barbula* (Rossmässler, 1838), G: *O.* cf. *barbula* (atypical population with unkeeled shells) and H-N: *O. barbella* (Servain, 1880); drawings show genitalia *in situ*, partly dissected to reveal penis and epiphallus, but with only distal ends of penial retractor muscle and vas deferens drawn. A, B: 9 Jan. 2011, by Paul do Taipal near Montemor-o-Velho, Beira Litoral; C: 13 Jan. 2011, summit area of Serra de Sico, Beira Litoral; D: 12 Feb. 2008, Serro Ventoso, Estremadura; E: 29 Apr. 2011, just NE. of Ansião, Beira Litoral; F: 12 Feb. 2011, Serra da Arrábida, Estremadura, population coexisting with *O. barbella*, cf. Fig. 2L; G: 4 June 2011, 2 km NNE. of S. Pedro de Moel, Estremadura, individual with longest epiphallus and (uniquely) a single minute flagellum; H: 20 Oct. 2008, Cerrinho das Neve, Mértola, Baixo Alentejo, Topotype; I: 15 Jan. 2011, SW. of Proença-a-Velha, Beira Baixa; J: 5 Feb. 2011, W. slope of Foia, Algarve; K: 28 Jan. 2011, by N2 NNW. of Alportel, Algarve; L: 12 Feb. 2011, Serra da Arrábida, Estremadura, population coexisting with *O. barbula*, cf. Fig. 2F; M: 3 May 2011, S. of Costa Nova do Prado, Beira Litoral; N: 27 Oct. 2010, 1 km NW. of Gafanha do Areão, Beira Litoral (all specimens in Collection of G.A. and D.T. Holyoak). Abbreviations as in Figure 1, plus or: ommatophore (with black or grey parts stippled) and its retractor muscle.

(Página derecha) Figura 2. Genitales masculinos distales en ejemplares representativos de Oestophora *de Portugal. A-F:* O. barbula *(Rossmässler, 1838), G:* O. *cf.* barbula *(población atípica, con conchas sin quilla) y H-N:* O. barbella *(Servain, 1880); los dibujos muestran los genitales* in situ, *diseccionados en parte para revelar el pene y el epifalo, pero representando sólo los extremos distales de los músculos retractores del pene y del vas deferens. A, B: 9 ene. 2011, junto a Paul do Taipal cerca de Montemor-o-Velho, Beira Litoral; C: 13 ene. 2011, zona de la cumbre de la Serra de Sico, Beira Litoral; D: 12 feb. 2008, Serro Ventoso, Estremadura; E: 29 abr. 2011, inmediatamente al NE. de Ansião, Beira Litoral; F: 12 feb. 2011, Serra da Arrábida, Estremadura, la población conviviendo con* O. barbella, *véase Fig. 2L; G: 4 jun. 2011, dos km. al NNE de S. Pedro de Moel, Estremadura, ejemplar con el mayor epifalo y (singularmente) un solo flagelo diminuto; H: 20 oct. 2008, Cerrinho das Neve, Mértola, Baixo Alentejo, topotipo; I: 15 ene. 2011, SO. de Proença-a-Velha, Beira Baixa; J: 5 feb. 2011, ladera oeste de Foia, Algarve; K: 28 ene. 2011, por la N2, NNO. de Alportel, Algarve; L: 12 feb. 2011, Serra da Arrábida, Estremadura, la población conviviendo con* O. barbula, *véase Fig. 2F; M: 3 may. 2011, S. de Costa Nova do Prado, Beira Litoral; N: 27 oct. 2010, 1 km NO. de Gafanha do Areão, Beira Litoral (todos los ejemplares en la colección de G.A. y D.T. Holyoak). Abreviaturas como en la Figura 1, además de or: ommatóforo (con partes negras o gris punteadas) y su músculo retractor.*

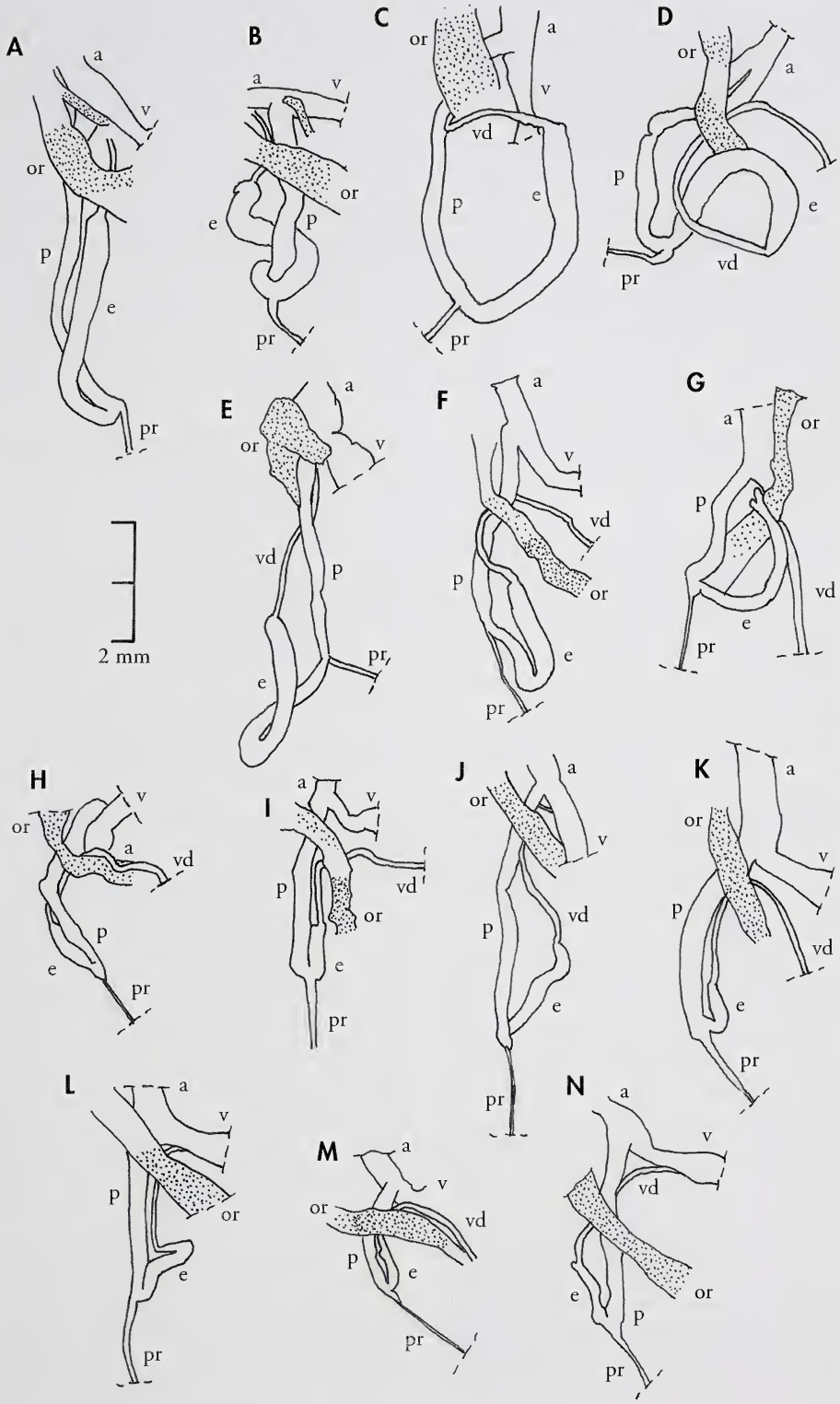
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Table II. Measurements of shells of *Oestophora barbula* and *O. barbella*. Data are given only for populations identified anatomically from epiphallus structure by the authors, for which 7 or more adult shells were available (specimens in authors' collection). N= number of individuals; s.d.= sample standard deviation. Rock types at each site are coded as follows, DS: coastal sand dunes; LB: limestone boulders placed to reinforce river banks, and a bridge abutment; Ls: limestone bedrock; Sh: shale; Sl: slate; Ss: sandstone.

Tabla II. Mediciones de conchas de Oestophora barbula *y* O. barbella. *Los datos se dan sólo para las poblaciones identificadas por los autores a partir de la estructura anatómica del epifalo, de las cuales se disponía de 7 o más conchas de adultos (ejemplares en la colección de los autores). N= número de individuos; s.d.= Desviación estándar de la muestra. Tipos de roca en cada sitio representados como sigue, DS: dunas de arena costeras; LB: rocas calizas formando riberas artificiales o el embasamiento de un puente; Ls: afloramiento de roca caliza; Sh: esquistos; Sl: pizarras; Ss: areniscas.*

Site	Locality	Rock	N	Breadth				Height				Whorls			
				max	min	mean	s.d.	max	min	mean	s.d.	max	min	mean	s.d.
O. barbula															
P129	Serra da Arrábida	Ls	22	9.5	7.5	8.51	0.546	4.9	3.5	4.20	0.402	5.7	5.0	5.41	0.229
P130	Serra da Arrábida	Ls	66	10.9	8.8	9.65	0.501	5.2	3.9	4.47	0.254	6.1	5.1	5.48	0.228
P131	Serra da Arrábida	Ls	11	11.0	9.4	10.34	0.607	4.9	3.8	4.49	0.324	5.7	5.0	5.35	0.246
P98	Serra de Sico	Ls	12	12.3	10.6	11.54	0.512	5.9	4.8	5.37	0.317	6.2	5.3	5.83	0.218
P41	SE. of Moitas Venda	Ls	27	13.0	10.5	11.65	0.605	6.0	4.3	4.93	0.376	6.2	5.3	5.74	0.274
P79	SW. of Alfarelos	Ls	12	12.6	10.7	11.68	0.636	5.7	4.5	5.16	0.446	5.8	5.1	5.44	0.215
P59	SW. of Serra Ventoso	Ls	13	12.9	11.4	12.17	0.435	5.7	4.4	5.07	0.343	6.3	5.3	5.89	0.312
P96	near Paul do Taipal	Ls	9	12.7	12.2	12.49	0.162	5.6	5.0	5.42	0.186	5.9	5.7	5.78	0.067
P73d	WNW. of Ansião	Ls	24	13.7	11.6	12.67	0.585	6.4	5.0	5.67	0.399	6.3	5.4	5.92	0.245
O. barbula?															
P67/ P161	NE. S. Pedro de Moel	LB	23	10.2	8.8	9.43	0.452	5.0	4.1	4.60	0.283	6.2	5.3	5.69	0.299
O. barbella															
P100	SW. Proença-a-Velha	Sl	8	8.8	7.2	7.78	0.526	4.3	3.4	3.74	0.320	5.7	4.3	4.76	0.441
P88	W. of Ladoeiro	Sl	15	9.4	6.8	8.28	0.713	4.8	3.1	3.98	0.487	5.6	4.3	4.99	0.344
P76	NW. Gafanha do Areão	DS	39	10.2	8.2	9.47	0.496	5.5	3.8	4.66	0.334	5.8	4.9	5.50	0.210
P97	S. of São Pedro	DS	14	10.5	8.7	9.55	0.556	5.2	4.2	4.76	0.295	5.9	5.2	5.53	0.205
P128	Serra da Arrábida	Ls	28	10.7	8.5	9.58	0.573	5.3	3.9	4.66	0.313	5.9	5.2	5.52	0.206
P119	Serra de São Miguel	Ls	8	10.6	8.6	9.60	0.697	5.2	4.3	4.66	0.297	5.5	4.8	5.18	0.231
P144	S. of C. N. do Prado	DS	7	11.2	10.1	10.60	0.443	4.7	4.1	4.44	0.215	6.2	5.8	6.07	0.160
P129	Serra da Arrábida	Ls	16	11.6	9.8	10.63	0.440	5.7	4.6	5.05	0.344	5.9	5.5	5.71	0.109
P80	N. of Ameal	LB	15	11.8	9.9	10.81	0.579	5.6	4.5	5.01	0.370	6.2	5.4	5.74	0.229
P110	NW. from Ameixial	Sl, Sh	7	13.3	10.5	11.73	1.126	6.0	4.8	5.37	0.544	6.1	5.2	5.74	0.299
P37	W. edge Sertã	Sl	7	13.5	11.4	12.49	0.851	6.0	5.5	5.81	0.212	6.1	5.5	5.76	0.230
P72	Barcoila, nr Cabeçudo	Sl	7	13.6	11.8	12.51	0.654	6.6	5.7	6.03	0.350	5.9	5.4	5.74	0.181
P106	NNW. of Alportel	Sl, Ss	10	14.2	12.0	13.54	0.631	6.0	5.5	5.80	0.194	5.7	5.2	5.54	0.190

generally regarded as a distinctive endemic species restricted to a small coastal region in S. France (Depts Pyrénées Orientales and Var) and NE. Spain (Prov. Gerona) (Puente, Altonaga, Prieto and Ruiz, 1998: 47). Shells of these taxa have very little in common, *O. lusitanica* having a rounded shell periphery and no apertural teeth, *M. rangianus* having a sharp keel and prominent apertural teeth. It is unclear whether the Portuguese specimens des-

Table III. Relative width of the umbilicus in shells of *Oestophora barbula*, *O. barbella* and a population of *O.* cf. *barbula* from near S. Pedro de Moel (Estremadura). The data on *O. barbula* are based on 20 representative mature shells selected from 6 populations; those on *O. barbella* on 22 representative mature shells from 7 populations within western-central Portugal (Coimbra to Serra da Arrábida). N = number of shells.

Tabla III. Anchura relativa del ombligo en conchas de Oestophora barbula, O. barbella *y una población de* O. *cf.* barbula *de cerca de S. Pedro de Moel (Estremadura). Los datos de* O. barbula *se basan en 20 conchas de individuos maduros seleccionadas en 6 poblaciones, los de* O. barbella *en 22 conchas de individuos maduros de 7 poblaciones en el oeste y centro de Portugal (Coimbra hasta Serra da Arrábida). N = número de conchas.*

Width of umbilicus as per cent of shell breadth		12 -13	13 -14	14 -15	15 -16	16 -17	17 -18	18 -19	19 -20	20 -21	21 -22	22 -23	mean
O. barbula	N	-	-	-	-	4	5	5	4	1	1	-	18.35%
O. barbella	N	-	-	-	-	-	-	2	9	5	2	4	20.38%
O. cf. *barbula* samples P67/161 from S. Pedro de Moel	N	1	1	4	2	7	4	1	-	-	-	-	15.98%

cribed by Seixas were *O. lusitanica* or *O. barbula sensu lato*, since the shell description does not mention teeth. Her drawing of the genital anatomy (SEIXAS, 1976: 36, Fig. 8D) is also unclear, with the organ labelled "p."[enis] apparently representing the accessory sac on the vagina and hence no distal male genitalia were shown. In view of these uncertainties the information given by Seixas seems best disregarded.

Shell characters. Shells of *O. barbula* and *O. barbella* have been compared closely using samples identified from epiphallus structure. The most consistent difference is that *O. barbula* has a sharp to very sharp peripheral keel on the body whorl of adult shells, whereas most *O. barbella* have the periphery lacking a keel (slightly angled to bluntly keeled or rounded) (Figs. 3, 4). Only a very small minority of shells of *O. barbella* have a keel sufficiently developed to allow confusion with shells of *O. barbula* (e.g. some shells from Verride, Beira Litoral: Fig. 4O).

CASTILLEJO *ET AL.* (1987) found that development of a peripheral keel is quite variable within some local populations in the Serra da Estrela (Beira Alta) that we interpret as being composed entirely of *O. barbella*. MATOS (2004: 105) claimed that populations of *O. barbula* [*sensu lato*], both wild and reared under laboratory conditions, frequently show shells with a more or less strong equatorial keel. The proportion of keeled individuals was said to vary around 20-28% in a single population or in the total population, these values corresponding to typical Mendelian segregation of a recessive gene, according to results then awaiting publication. With *O. barbella* we have not found any clear demarcation between keeled, slightly keeled, slightly angled (commonest type) and rounded shells in most populations, whereas *O. barbula* is consistently keeled. PUENTE (1996: 88) mentioned shells as being clearly rounded in five Spanish populations [of the taxon we regard as *O. barbella*] and clearly angular in one population (from Las Correderas in Prov. Jaén).

The only other shell character likely to be helpful in distinguishing the two species is that most populations of *O. barbula* have a proportionately narrower umbilicus than most populations of *O. barbella*, at least within western-central Portugal (Table III). With careful measurements of adult shells (see above), umbilicus widths of less than 18% of shell breadth were found only in *O. barbula*, whereas those above 20% were found mainly in *O. barbella*. The small difference in umbilicus width is appa-

rently due mainly to the tendency for *O. barbula* to have the body whorl wider in proportion to its height, as reflected in the tendency for the shell mouth to be more elliptical in *O. barbula*, more rounded in *O. barbella*. Most shells from many populations of *O. barbella* show an umbilicus that becomes asymmetrical during growth because of the form of the body whorl, whereas the smaller umbilicus of *O. barbula* is usually more symmetrical. However, individual shells often contradict these generalisations.

Detailed data on shell sizes and number of whorls is presented in Table II, for populations that have been identified from the epiphallus structure and which include >6 adult shells, so that mean sizes, size ranges and standard deviations can be estimated with at least modest reliability. Shell size varies widely from locality to locality in both species, although *O. barbella* has populations with both smaller and larger mean shell breadths than *O. barbula* (Table II).

It is difficult to detect any consistent regional patterns in the distribution of mean shell size for either species, with little hint of any orderly pattern in size or shape that might be used to define geographical subspecies. The most obvious overall trend is apparently towards small shell size in drier local habitats or regions and larger shell size in wetter or more humid situations. This is most obvious in *O. barbella*, where the two samples with smallest shell breadth (P88, P100) are from areas of eastern Beira Baixa with low regional rainfall and hot dry summers, followed by two samples from coastal sand dunes (P76, P97), then three samples from open karst areas on Mesozoic limestone hills (P128 and P129 on Serra da Arrábida, P119 from Serra de São Miguel). The largest shells are from sites on hills of slate and other siliceous rocks, with relatively high rainfall. A review by Goodfriend (1986) similarly found that within a land-snail species larger shell size is often associated with moist environments. Smaller size was also sometimes recorded at higher population densities, apparently through effects of pheromones on growth rates, but the latter tendency was not apparent in these *Oestophora* species. Reduced size of *O. barbula* living sympatrically with *O. barbella* at one of the sites in the Serra da Arrábida might be a consequence of interspecific competition, as discussed below.

The ratio of shell height (H) to shell breadth (B) overlaps very widely in *O. barbula* and *O. barbella*, population means being within an overall range of H = 0.42-0.49 B in the former species, 0.42-0.50 B in the latter species. The number of shell whorls tends to be slightly higher in *O. barbula* (overall range 5.0-6.3, population means 5.35-5.92) than in *O. barbella* (overall range 4.3-6.2, population means 4.76-5.76) (Table II), but there is much overlap and a strong tendency within populations of both species for smaller shells to be comprised of fewer whorls. Development of the palatal teeth is rather variable, with the inner tooth being absent in a small percentage of *O. barbella*, but apparently always being present in mature *O. barbula*.

Although shells of both species seem at first sight to have rather variable surface sculpture, close study at high magnification (up to ×40) with a stereomicroscope suggests that both have a very similar basic pattern that does not allow species identification. The surface of the protoconch is virtually smooth, the same lack of sculpture continuing on whorl 0-0.3. Whorl 0.3-0.7 has irregular low radial ribs, formed by elongate papillae. Whorls 0.7-1.4 have about 8-12 raised ridges, which show some tendency to spiral around the shell whorl but soon descend into the lower suture; around whorls 1.4-1.6 these ridges are reduced to spiral lines of low scales. After whorl 1.6 the sculpture of the mature teleoconch develops, with increasingly prominent, long, low radial ribs, with small raised papillae on a rectilinear grid in the valleys between the ribs. Much of the apparent variability in sculpture on samples of mature shells results from differences in the strength (height) of ribs on later whorls of the teleoconch and the extent to which these are developed on the underside of the

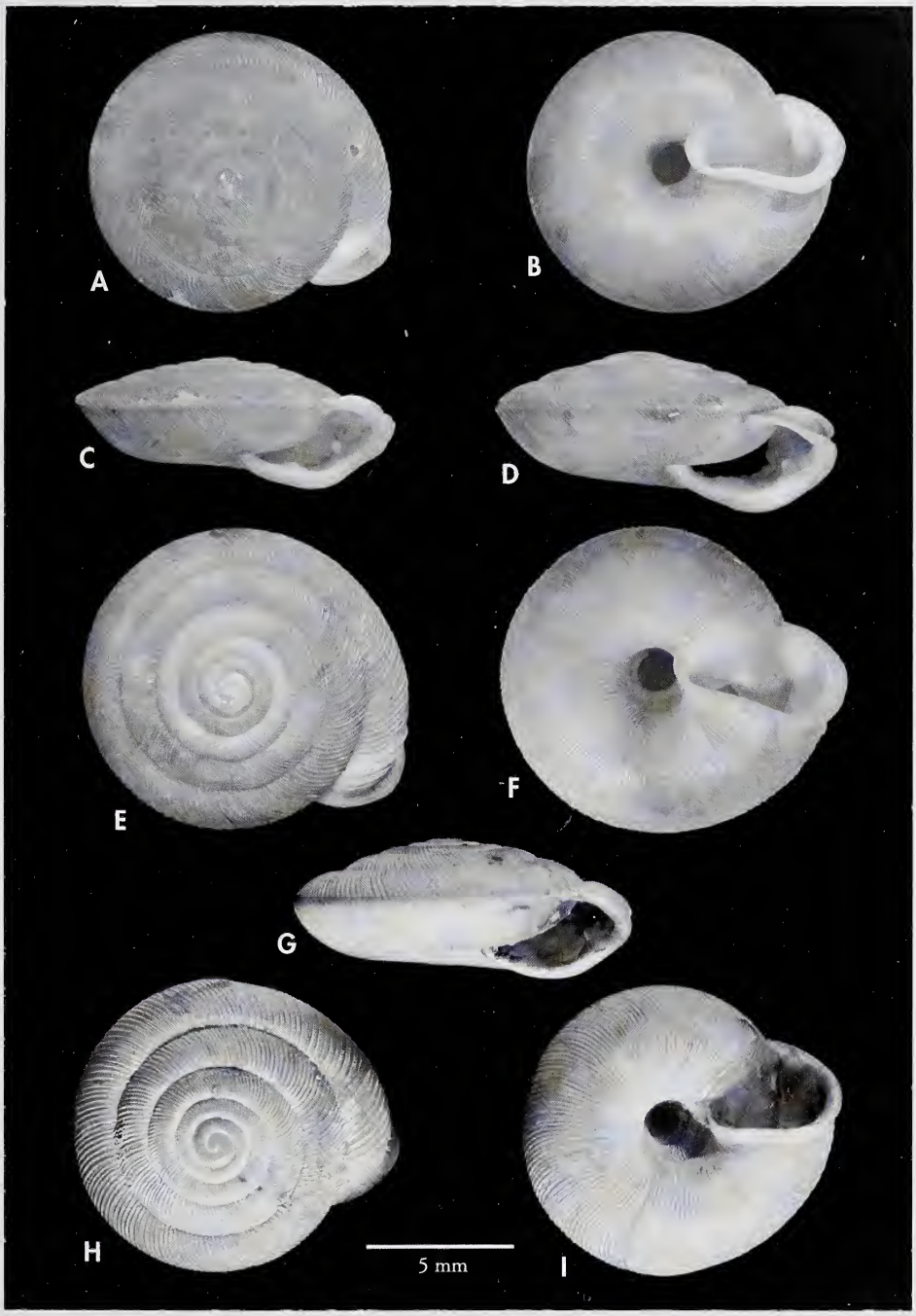


Figure 3. Shells of type material of *Oestophora barbula* (Rossmässler, 1838) and *O. barbella* (Servain, 1880). A-C: lectotype of *O. barbula* (SMF 7036); D-F: paralectotype of *O. barbula* (SMF 7035); G-I: lectotype of *O. barbella* (MHNG 17059A).

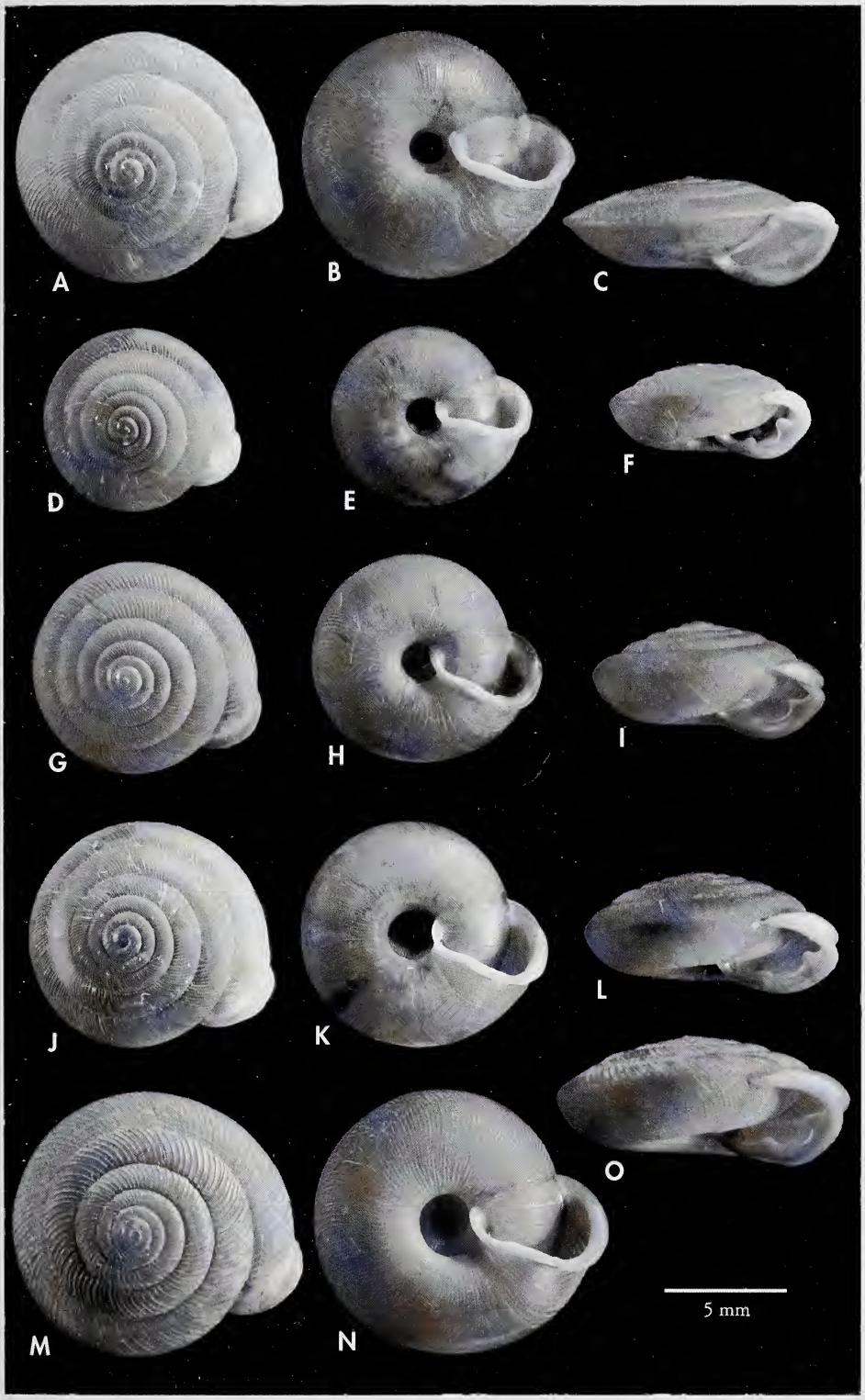
Figura 3. Conchas del material tipo de Oestophora barbula *(Rossmässler, 1838) y* O. barbella *(Servain, 1880). A-C: lectotipo de* O. barbula *(SMF 7036); D-F: paralectotipo de* O. barbula *(SMF 7035); G-I: lectotipo de* O. barbella *(MHNG 17059A).*

shell. The small papillae between the teleoconch ribs soon disappear in worn or corroded shells.

Geographical distribution. Records of *O. barbula* and *O. barbella* from Portugal are mapped in Figure 5. *O. barbula* confirmed by dissection was recorded only from western-central Portugal, from near Coimbra (Beira Litoral) southwards to the Serra da Arrábida (Estremadura), occurring inland only to the eastern limits of the limestone hills of SE. Beira Litoral, westernmost Beira Baixa and N. Ribatejo provinces. *O. barbella* has a much wider range, apparently throughout Portugal, since it is likely that the lack of records from much of Alentejo and parts of northern-central Portugal merely reflects sparsity of recent recording of land snails there. Since *O. barbula* appears to be endemic to Portugal, the many records mapped by PUENTE (1996: 87) for *O. barbula* [*sensu lato*] from western and southern Spain can probably all be referred to *O. barbella*. Her published figures of genital anatomy (PUENTE, 1996: 84-85) confirm *O. barbella* as occurring in the following Spanish provinces: Asturias, Cáceres, Huelva, Jaén, León, Lugo and Zamora. Many published figures of unkeeled shells from Spain also imply that *O. barbella* occurs widely there. Unkeeled shells figured from the Azores (BACKHUYS, 1975), two shells seen from Terceira, Azores and figures of Madeiran shells (SEDDON, 2008) also strongly suggest it is *O. barbella* rather than *O. barbula* that occurs in these archipelagos, where it is likely to have been introduced by man. A population established near Driebergen, province of Utrecht, the Netherlands from at least 1994 to 2010 (DEES, 2011) also has unkeeled shells apparent from published photos. However, Quaternary fossil specimens from Mallorca that have been reported as *O. barbula* are now reinterpreted as an extinct endemic species named as *Darderia bellverica* by ALTABA (2006).

Habitat preferences. Descriptions of habitats where the present authors collected specimens of known identity (mainly confirmed anatomically) were recorded from 2001-2011 at 81 localities in Portugal or neighbouring provinces of Spain. Only one locality had both species living together (see next section). Both species occur mainly in the lowlands and on low hills. Altitudinal ranges were recorded for *O. barbula* as *ca* 13 m (1 km SW. of Alfarelos, Beira Litoral) to 548 m (high on Serra de Sico, Beira Litoral); for *O. barbella* as 7-10 m (on coastal sand du-

(Right page) Figure 4. Shells of (A-F) *Oestophora barbula* (Rossmässler, 1838), (G-I) *O.* cf. *barbula* and (J-O) *O. barbella* (Servain, 1880) to show variability between populations. A-C: 19 July 2010, *ca* 1 km SW. of Serro Ventoso, Estremadura, from restricted type locality; D-F: 12 Feb. 2011, Serra da Arrábida, Estremadura (29SNC020602), from population coexisting with *O. barbella*, see Figures 4J-L; G-I: 4 June 2011, 2 km NNE. of S. Pedro de Moel, Estremadura, from apparently atypical population of *O. barbula* with small unkeeled shells; J-L: 12 Feb. 2011, Serra da Arrábida, Estremadura (29SNC020602), from population coexisting with *O. barbula*, see Figures 4D-F; M-O: 3 Nov. 2010, NW. of Verride near Rio Mondego, Beira Litoral, from population with shell keel more developed than in most *O. barbella* (all specimens in Collection of G.A. and D.T. Holyoak).
(Página derecha) Figura 4. Conchas de (A-F) Oestophora barbula *(Rossmässler, 1838), (G-I)* O. *cf.* barbula *y (J-O)* O. barbella *(Servain, 1880) para mostrar la variabilidad entre poblaciones. A-C: 19 jul. 2010, aproximadamente 1 km. SO de Serro Ventoso, Estremadura, de la localidad-tipo restringida; D-F: 12 feb. 2011, Serra da Arrábida, Estremadura (29SNC020602), de la población conviviendo con* O. barbella, *véase Figuras 4J-L; G-I: 4 jun. 2011, 2 km. NNE de S. Pedro de Moel, Estremadura, de la población aparentemente atípica de* O. barbula *con pequeñas conchas sin quilla; J-L: 12 feb. 2011, Serra da Arrábida, Estremadura (29SNC020602), de la población conviviendo con* O. barbula, *véase Figuras 4D-F; M-O: 3 nov. 2010, NO. de Verride cerca de Río Mondego, Beira Litoral, de la población con la quilla de la concha más desarrollada que en la mayoría de* O. barbella *(todos los ejemplares en la colección de G.A. y D.T. Holyoak).*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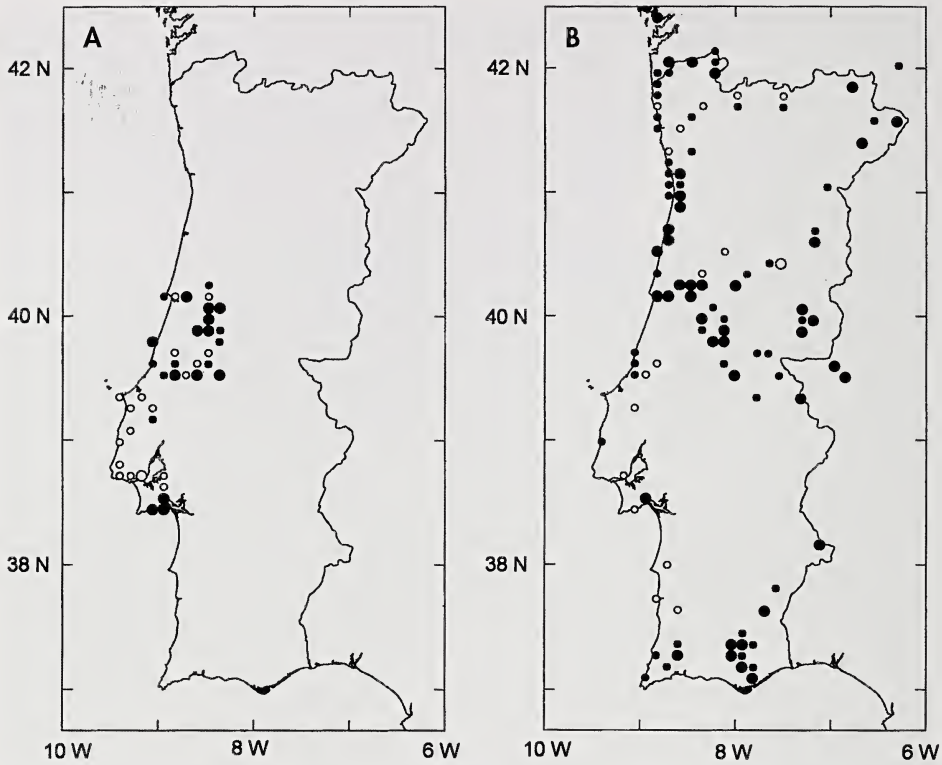

Figure 5. Distribution of (A) *Oestophora barbula* (Rossmässler, 1838) and (B) *O. barbella* (Servain, 1880) in Portugal and adjoining regions of Spain. ●: collected since 1999 by authors or Álvaro De Oliveira, confirmed by dissection; •: collected since 1999 by authors or Álvaro De Oliveira, shells only; ○: collected before 2000, confirmed by dissection (HESSE, 1931 or CASTILLEJO *ET AL.*, 1987); ○: collected before 2000, shells only (mainly confirmed by Álvaro De Oliveira).

Figura 5. Distribución de (A) Oestophora barbula *(Rossmässler, 1838) y (B)* O. barbella *(Servain, 1880) en Portugal y en las regiones cercanas de España.* ●*: recogidos desde 1999 por los autores o por Álvaro de Oliveira, confirmados por la disección;* •*: recogidos desde 1999 por los autores o por Álvaro de Oliveira, solo conchas;* ○*: recogidos antes de 2000, confirmados por la disección (HESSE, 1931 o CASTILLEJO* ET AL.*, 1987);* ○*: recogidos antes de 2000, sólo conchas (principalmente confirmados por Álvaro de Oliveira).*

nes) up to 890 m (Foia, Algarve), 1015 m (near summit of Pico São Mamede, Alto Alentejo), 1050 m (Sabugeiro, Beira Alta) and at least 1080 m (N. of Lamas de Mouro, Minho). Both species were recorded in wooded and open sites, living specimens most often being found resting beneath substantial boulders.

O. barbula was found at 21 localities, 20 of which were on bedrock of Cretaceous or Jurassic limestone, mainly where the rock was exposed in crags or as limestone pavements or large boulders, but predominantly in dry-stone walls at a few sites. At a single locality (*ca* 2 km NNE. of Santa Cita, Ribatejo) it was found living on alluvial banks of a lowland river, albeit within a river catchment having much limestone bedrock. At the latter locality limestone boulders had been imported to provide protection for parts of the river bank, so it is possible that *O. barbula* reached the site with these or that it arrived there by drifting down the river. Possible occurrence of a second population of this species in a different habitat (at site P67/P161) is discussed above.

O. barbella was recorded at 60 localities, over a much wider range of rock types than those where *O. barbula* was found, including acidic lithologies. Sedimentary rock types characterised less than half of the localities, with records from sites with exposed limestone rock (10 sites; 16.7%), man-made banks of limestone boulders (2 sites; 3.3%), sandstone (3 sites; 5.0%), and unconsolidated sediments of calcareous sand in coastal dunes (8 sites; 13.3%) and sands and gravel capping limestone near the coast (1 site; 1.7%). A majority of records were from localities with various metamorphic rocks, recorded as slates (mainly Paleozoic) (11 sites; 18.3%), slate and shale (2 sites; 3.3%), slate and schist (3 sites; 5.0 %), slate and quartzite (1 site; 1.7%), quartzite (5 sites; 8.3%), granite (11 sites; 18.3%) and Foiaite (2 sites; 3.3%). The single remaining site (1.7%) was along a concrete roadside wall with no rock exposed nearby. Some sites with *O. barbella* were more disturbed by man than those tolerated by *O. barbula*, including edges of cultivated land and managed road verges.

It is noteworthy that although *O. barbella* was recorded at 12 sites with limestone rocks, as noted above, the species was normally absent from places with exposed Cretaceous or Jurassic limestone within the range of *O. barbula* (i.e. from Lisbon north to around Coimbra: Fig. 5). Nevertheless, over that extensive region *O. barbella* was found on man-made banks of limestone boulders near rivers (2 sites) and on coastal dunes (3 sites), so it appears to either avoid the rocky sites with natural Mesozoic limestones or to be excluded from them by the presence of the relatively common *O. barbula*. Further evidence that competitive exclusion might occur is that outside the range of *O. barbula*, *O. barbella* was found to occur widely on outcropping Mesozoic limestone. In the Algarve it was usually found (7 sites) at much lower density than the accompanying *Gittenbergeria turriplana* (Morelet, 1845) (Trissexodontidae), an Algarve endemic with a larger sharply keeled shell; it was also found among hard limestone rocks in the Sierra de la Encina (Prov. Ourense) (1 site). Where *O. barbella* meets the southern edge of the range of *O. barbula* in the Serra da Arrábida (Estremadura), *O. barbella* was found alone at one site (in plenty), *O. barbula* was found alone (in plenty) at two sites and both species coexisted at a fourth site, as follows.

Coexistence of O. barbula *and* O. barbella. Although the ranges of *O. barbula* and *O. barbella* approach closely and probably interdigitate around Coimbra and Figueira da Foz (Beira Litoral), they were not found living together and their records were from different habitats, as described above. However, at one of four sites studied on the Serra da Arrábida (P129 at 29SNC020602) the two species were found living together, at 380-388 m altitude on N.-, NW. and S.-facing rocky limestone slopes with patches of scrub. Visits on 17 May 2007 and 12 February 2011 amassed 22 adult *O. barbula* (4 living, 18 shells) and 16 adult *O. barbella* (8 living, 8 shells) from within a 100 metre radius, both species twice being found together alive under a single boulder. The same two visits to the Serra da Arrábida revealed *O. barbella* occurring alone at one site (P128 at 29SNC032604, 45 adults, from rocky limestone hilltop with low scrub) and *O. barbula* occurring alone at two other sites (P130 at 29SMC999576 to 29SNC000577, 68 adults, limestone road-cutting, scree and slope with tall scrub locally; P131 at 29SNC01175874, 12 adults, roadside at base of cutting in limestone rock). The identity of specimens from all four sites was confirmed by study of the epiphallus (in several individuals from three sites, one from the fourth) and all adult shells were easily separated by the presence of a sharp peripheral keel in *O. barbula* alone (cf. Figs. 4D-F and 4J-L).

It is noteworthy that at these four sites in the Serra da Arrábida shell size of both species is rather similar where each occurs alone, but it diverges markedly where the two species coexist (Table II, Figs. 4D-F and 4J-L). Thus, mean shell breadth for *O. barbella* occurring alone (site P128) is 9.58 mm, and

for *O. barbula* occurring alone it is 9.65 mm (site P130) and 10.34 mm (site P131). At site P129 with both species living together, *O. barbella* is larger at 10.63 mm whereas *O. barbula* is smaller at 8.51 mm.

Based on data listed in Table II, statistical significance of the differences among sample means for shell breadth was calculated pair-wise for sites P128-P131. After it was established with Snedecor's *F* that there is no significant difference of the respective variance ratio between each of the pair of samples compared ($p > 0.05$), values of Student's *t* were calculated applying Bessel's correction. These results confirm that at site P129 *O. barbula* is smaller than at neighbouring sites (P130: $t = 8.94$, 86 d.f., $p < 0.001$; P131: $t = 8.47$, 31 d.f., $p < 0.001$) whereas *O. barbella* is larger than at a neighbouring site (P128: $t = 6.18$, 42 d.f., $p < 0.001$); they also confirm the size difference between the two species at site P129 ($t = 3.02$, 36 d.f., $p < 0.01$).

Furthermore, the small size of *O. barbula* at site P129 appears to be a special effect of sympatry with *O. barbella* rather than due to chance alone, since this is much the smallest of 30 populations of *O. barbula* encountered anywhere in this study (cf. Table II), with the possible exception of specimens from P67/P161 (see above) which have unkeeled shells and somewhat ambiguous genital anatomy so some doubt remains about the species identification.

These differences in shell size between the two species are suggestive of the phenomenon of "character displacement" (Brown and Wilson, 1956; Pianka, 1974), which refers to increased differences between species where they occur together. It is argued that in such cases selective pressures from interspecific competition have tended to maximise the differences in size and hence in resource utilisation among coexisting species (Brown, 1975; Diamond, 1975). This presumes that differences present in sympatry are inherited and allow an evolutionary response. Fenchel (1975) proposed this explanation for size differences developed between some mud-snail species (Hydrobiidae) only when they coexist, but Saloniemi (1993) proposed an environmental explanation whereby only those habitat types able to support two coexisting mud-snail species allow one of the species to grow large. Subsequently, experimental studies by Gorbushin (1996) pointed to the size differences in sympatry being an effect of direct competition for food, affecting one of the species more than the other, not an inherited adaptive response. In fact, most examples of "character displacement" involve birds or other vertebrates where size differences in adults of two species can allow partitioning of resources. As pointed out by Hylleberg (1976) and stressed by Gorbushin (1996) it is unlikely that coexisting species of snail can partition resources in the same manner because a large part of their populations will be comprised of immatures that show extensive size overlap between species. Hence, "character divergence" in sympatric snails may be evidence of interspecific competition, but need not involve inherited size differences.

TAXONOMIC DISCUSSION

Authorship, lectotypification and type-locality of *O. barbula*

Hidalgo (1875: 42) cited the name *Helix bituberculata* A. Férussac, 1837, from the catalogue published in Paris for the sale of the Férussac Collection (on p. 4, from Portugal). This name was evidently a *nomen nudum* that Hidalgo interpreted as representing [*Helix*] *barbula* Charpentier.

Rossmässler (1838: 11, Taf. 32, Fig. 451) gave the first description and figures of the species, as *Helix barbula* v. Charp., with "Syn. *Helix barbula v. Charp. in litt.*" also listed. Subsequently, Hesse (1931: 52) listed the authorship of the name as "*Oestophora barbula* (Chrp.) Rssm." and Ortiz de Zárate Lopez (1962: 91), Castillejo (1984: 128) and Castillejo *et al.* (1987) all adopted "*Oestophora* (*Oestophora*) *barbula* (de Charpentier)". However, Puente (1996: 82) accepted Rossmässler as author and

this appears to be correct on the basis that Charpentier presumably provided the name whereas Rossmässler was responsible for the description, so only the latter can be regarded as the author responsible for its naming.

The collection of the Forschungsinstitut Senckenberg contains two shells labelled as those of *Helix barbula* figured by Rossmässler (*loc. cit.*), one more sharply keeled (SMF 7036, shell diameter 11.1 mm: Figs. 3A-C) than the other (SMF 7035, diameter 11.9 mm: Figs. 3D-F). SMF 7035 had been labelled as "lectotype" by the late Dr. Adolf Zilch, but the designation is invalid since it was never published. Close study of Rossmässler's fig. 451 (*loc. cit.*; especially the first of the four figures) suggests the figured specimen was actually the more sharply keeled SMF 7036. Since SMF 7036 also shows the clearest development of the shell keel characteristic of the taxon with a large epiphallus from western-central Portugal this shell is selected here as lectotype, leaving SMF 7035 as a paralectotype.

ROSSMÄSSLER (1838: 11) recorded the provenance of the type material as "von *Holl* auf seiner Aktien-reise in Portugal gesammelt". Searches have produced no additional information to indicate a more precise locality. This is unfortunate because a small proportion of shells of *O. barbella* appear indistinguishable from the lectotype of *O. barbula*. We cannot designate a neotype for *O. barbula* based on a specimen with large penial epiphallus because undoubted syntype shells still exist (ICZN Art. 75(a)). Although the ICZN could itself set aside the existing type material and designate a neotype under its plenary powers if a detailed application were to be made (Recommendation 75E), it would need to be demonstrated that such action "is essential for solving a complex zoological problem" (Art. 75). MAYR (1969: 375, 56.B.3) concluded that "in most cases [of this type] no such neotype designation will be needed", adding (MAYR, 1969: 374-375, 56.B.3) that the ICZN Code "contains no provisions regarding what to do when the type lacks all diagnostic characters".

A convenient solution to this problem lies in restricting the type-locality, which was given only as "Portugal" in the original description of *O. barbula* and has never before been restricted, either directly, or by our designation of a lectotype. Following ICZN Recommendation 72H on restricting type localities, only its section (4) can be applied: "as a last resort, and without prejudice to other clarification, localities within the known range of the taxon or from which specimens referred to the taxon had been taken". Hence we restrict the type-locality of *O. barbula* to "limestone crags *ca* 1 km SW. of Serro Ventoso, S. of Porto de Mós, Estremadura, in central Portugal". This locality excludes any likelihood of *O. barbella* being present, whereas anatomically verified *O. barbula* with large keeled shells (Figs. 4A-C) resembling that of the lectotype are abundant there. Although this action is arbitrary with respect to Rossmässler's material, a first reviser may designate a restricted type locality. Such a restriction may later be set aside if it conflicts with the available evidence, but only if the case is unequivocal (MAYR, 1969: 377, note 2).

Authorship and lectotypification of *O. barbella*

Type specimens of *Helix barbella* (SERVAIN, 1880: 66) were studied on loan from Muséum d'Histoire Naturelle, Ville de Genève (MHNG). These notes describe this material, set out reasons for believing that it forms all or part of the original "type series" and provide a background to selection of a lectotype for the species.

The type material studied comprised two similar corked glass tubes with round bases, each of them labelled on the outside with a blue edged label annotated as follows in ink:

Helix barbella Servain Mertola Portugal [11 shells; subsequently numbered at MHNG as 17059; cork with 51. written in ink].

Helix barbella Servain Lisbonne [1 shell; subsequently numbered as 17060; cork with 34. written in ink];

These two tubes are contained in a small card box that is glued to a larger wooden base. A label pasted on the bottom of the inside of the box states: *Helix Barbella*, Bourguignat in: Servain, Cat. Moll. Esp. p. 1880. A label pasted outside the box on the top of the wooden base has printed "Muséum de Genève Collection Bourguignat" and hand-written *Helix barbella* Bgt. [Localité] Portugal.

The box and its two labels evidently date from the curation of the material as part of Bourguignat's collection at MHNG. Their attribution of authorship to Bourguignat is probably erroneous because the labels on the two tubes give only Servain as author of the name, and this is in agreement with the original publication having Servain as sole author and also the original description making no mention of Bourguignat.

It can be inferred that these specimens from Bourguignat's collection form all or part of Servain's "type series" of *Helix barbella* for the following reasons, which taken together, leave no real doubts:

(1) The original collection of G. Servain has apparently not survived intact. At least, the list of collections by Dance (1986: Appendix IV) makes no mention of it.

(2) There is clear evidence that Servain worked closely with Bourguignat and apparently made at least some of his Spanish and Portuguese specimens available to him. The book by Servain (1880: 6) makes a lavish acknowledgement of Bourguignat (and no other collaborater) stating: "à notre excellent ami M. J. R. Bourguignat, nos remerciements pour son extrême obligeance, qui ne s'est jamais démentie à notre égard, et pour la complaisance avec laquelle il a bien voulu nous éclairer sur la valeur de nos espèces et mettre à notre disposition sa riche bibliothèque et son immense collection."

(3) Types of other Portuguese snails described in Servain (1880) appear to be in the Bourguignat collection. Thus, in dealing with *Candidula*, Gittenberger (1993: 283) points out that "Topotypes of nominal taxa described by G. Servain, found in the collection of J.R. Bourguignat, might in fact be syntypes donated by their author."

(4) The two localities given in the original description of *H. barbella* (Servain, 1880: 67) and those on tubes in the Bourguignat collection correspond exactly and the number of specimens from each of them also corresponds well. Thus, Servain wrote "Alluvions du Tage près de Lisbonne, où elle est rare. – Elle est assez abondante, à ce qu'il parait, aux alentours de Mertola en Portugal." The material of *H. barbella* in Bourguignat's collection comprises just two tubes, respectively from "Lisbonne" [1 shell] and "Mertola" [11 shells].

(5) The characters of the shells in the Bourguignat collection show unusual features which correspond exactly to parts of Servain's original description. Thus, Servain (1880: 67) states that there is only a single palatal tooth ("orné *seulement d'une grosse dent vers la région médiane* du borde externe": italics as in original). The Mertola material at MHNG (11 shells) has one shell with only a single tooth (outer palatal only), four shells giving a superficial impression of having only a single tooth (with a very weak or weak and rather inconspicuous inner tooth), one shell with the inner tooth almost obscured by the dried body; hence only the remaining five shells have a conspicuous and strong inner palatal tooth. The single shell at MHNG from "Lisbonne" also has only a small, weak inner palatal tooth. Occurrence of only a single palatal tooth is recurrent but rare in populations of the *O. barbula/O. barbella* group of taxa (Ortiz de Zárate Lopez, 1962; Castillejo *et al.*, 1987; Puente, 1996).

In the original description, Servain (1880: 67) also stated that the shell has "son dernier tour *aussi fortement lamellé en dessous qu'en dessus*" (italics as in original), i.e., the body whorl has ribbing on the underside as strong as that on the upperside. Ribbing in the MHNG material is present on the underside of all 12 shells and strong in some of them; five of the shells from Mertola have the ribbing

on the underside as strong or nearly as strong as that on the upperside. Generally, ribbing of shells in this species-group is rather variable, but it is infrequently as strong on the underside of the body whorl as it is on the upperside.

(6) The condition of the shell at MHNG from "Lisbonne" corresponds to the "Alluvions du Tage" of the original description: it is encrusted with silt on the outside of the spire and inside the shell mouth.

Overall, it seems there can be no certainty that all of Servain's original "type series" is now in the Bourguignat collection. However, the evidence that at least part of it is present there is compelling. Since the original Servain collection of shells no longer appears to exist, there is thus ample justification for selecting a lectotype from the Bourguignat collection at MHNG.

Therefore, a lectotype is designated here to fix application of the name *Helix barbella* Servain, 1880. The lectotype selected is from Mertola (i.e. Mértola) and is placed in a separate small tube and labelled as MHNG 17059A (Figs. 3G-I); it measures 11.2 mm in diameter, 4.5 mm in height and has 5.6 whorls, a weak inner palatal tooth and strong ribbing on the underside of the shell; traces of the body and dark staining suggest the animal was alive when collected. Ten paralectotypes from Mértola remain in the original tube (as 17059B); these have shell diameter 9.2-11.3 mm (mean 10.33, s.d. 0.79 mm), shell height 3.8-4.9 mm (mean 4.29, s.d. 0.39 mm), 4.8-5.7 whorls (mean 5.27, s.d. 0.24 whorls). One paralectotype from "Lisbonne" (17060) remains in its original tube; it has shell diameter 10.1 mm, shell height 4.7 mm and 5.4 whorls. All the shells of the "type series" of *O. barbella* have a rounded keel on the body whorl, less sharp than in either of the two syntypes of *O. barbula* Rossmässler.

The genital anatomy has been studied from two specimens of *O. barbella* collected recently at Mértola (20 Oct. 2008, Cerrinho das Neves, Mértola (29SPB1767), Mértola, Baixo Alentejo, leg. Álvaro De Oliveira; Collection of G.A. and D.T. Holyoak); both show a relatively short and weak penial epiphallus (Fig. 2H). The shells from these two specimens have been compared with the lectotype and ten paralectotypes from Mértola, which they resemble in the rounded keel on the body whorl and general form of the shell. These two recently collected shells are within the range of variation of the paralectotypes in their shell dimensions, weak/medium strength of ribbing on underside of body whorl and the medium/strong inner palatal tooth.

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APPENDIX. MATERIAL STUDIED.

Data are listed in sequence as country, province, locality name, habitat description, altitude, U.T.M. grid reference, date (YYYY.MM.DD), collector(s) followed by – then collector's field number, number of specimens, number of shells, collection, museum registration number, comments; successive entries are separated by semi-colons. Abbreviations: ÁDO = Álvaro De Oliveira, CGAH = Collection of G.A. and D.T. Holyoak, DTH = D.T. Holyoak, GAH = G.A. Holyoak, leg. = collected by, MHNG = Muséum d'Histore Naturelle, Ville de Genève, Switzerland, SMF = Forschungsinstitut Senckenberg, Germany, sh = number of intact adult shells (without preserved bodies), sp = total number of adult specimens with bodies preserved in alcohol (number of dissected adult specimens is given in parentheses).

O. barbella, Portugal, Algarve: *ca* 0.5 km S. of Bensafrim, base of N.-facing limestone crag, 76 m, 29S 05237/41116, 2011.02.06, GAH and DTH – P121, 2 sh, CGAH; W. slope of Foia, hillslopes with low metamorphic crags (Foyaite) and patchy cover of *Erica* and *Cistus*, grassland locally, 810 m, 29S 05347/41292, 2011.02.05, GAH and DTH – P120, (1) sp, CGAH; *ca* 0.5 km E. of summit of Foia (W. of Monchique), hilltop with blocks of metamorphic rock amongst low scrub, *ca* 890 m, 29SNB33, 2001.06.03, GAH, 5 sh, CGAH; E. end of Rocha da Pena, rocky limestone slope and plateau with patches of bushes, 460 m, 29S 05803/41234, 2011.01.28, GAH and DTH – P104, (1) sp, 4 sh, CGAH; E. end of Rocha da Pena, rocky limestone slope with patches of tall bushes, 462 m, 29S 058033/412344, 2011.01.31, GAH and DTH – P112, (1) sp, CGAH; by N2 at 4.5 km NW. along road from Ameixial, roadside cutting with steep slaty/shaley rock and patchy low herbs and grasses, 265 m, 29S 05898/413885, 2011.01.30, GAH and DTH – P110, (1) sp, 7 sh, CGAH; *ca* 2 km E. of Santa Barbara de Nexe, rocky limestone hill-slopes with patchy low scrub, 261 m, 29S 059428/410732, 2011.02.03, GAH and DTH – P117, 1 sh, not kept; by N2 NNW. of Alportel, rocky (slate and sandstone) slopes in open *Pinus*, *Quercus* and *Eucalyptus* woodland by road, 365 m, 29S 059569/411731, 2011.01.28, GAH and DTH – P106, (2) sp, 9 sh, CGAH; by N124 W. of Quintã, banks and steep bases of road cuttings in slaty/schist rock, with sparse *Cistus*, grasses and herbs, 211 m, 29S 059037/412121, 2011.01.31, GAH and DTH – P113, 1 sh, CGAH; by N2 S. of Ameixial, steep slaty/shaley roadside cuttings with sparse patches of grasses and herbs, 406 m, 29S 059164/413483, 2011.01.30, GAH and DTH – P111, (1) sp, CGAH; by N398 *ca* 2 km N. of Moncarapacho, limestone slope with low rocks and patches of scrub, *ca* 121 m, 29S 06068/41078, 2011.01.29, GAH and DTH – P108, (1) sp, 1 sh, CGAH; Serra de São Miguel (*ca* 4 km NW. of Moncarapacho), rocky limestone slopes with patchy scrub and grassland, 340 m, 29S 06043/41067, 2011.02.04, GAH and DTH – P119, (1) sp, 7 sh, CGAH; *ca* 3 km NNW. of Moncarapacho (just S. of A22), rocky limestone hillslope with patchy bushes, 131 m, 29S 060695/410771, 2011.02.04, GAH and DTH – P118, (1) sp, 1 sh, CGAH; just NW. of Barroqueira (*ca* 7 km NW. of Moncarapacho), rocky limestone slopes and quarries with patchy bushes, 183 m, 29S 060291/411092, 2011.01.29, GAH and DTH – P107, 2 sh, CGAH; Alto Alentejo: Belver castle, Gavião, 29SND8972, 2008.11.21, ÁDO, (3) sp, CGAH; by Rib. de Sor *ca* 4 km NW. of Monte da Pedra (NW. of Crato), granite rocks with sparse scrub near river, *ca* 183 m, 29SPD05, 2001.05.30, GAH, 7 sh, CGAH; N. end of Barragem da Povoa, granite walls and rocks in deciduous grove on reservoir margin, 320 m, 29SPD27, 2001.05.31, GAH, 1 sh, CGAH; Pico São Mamede, beneath boulders on sparsely vegetated N.-facing hillside near crags, *ca* 1015 m, 29S 06413/43527, 2007.05.15, GAH – 2007.5, (1) sp, 3 sh, CGAH; Azores: Duque da Terceira Garden, Angra do Heroismo, Ilha Terceira, 26NMH87, 2005.11.01, ÁDO, 2 sh, CGAH; Baixo Alentejo: by N2 at *ca* 1.5 km SSE. of Dogueno, unshaded road cuttings with exposed sandstone, sparse low vegetation, 338 m, 29S 059045/414242, 2011.01.30, GAH and DTH – P109, 2 sh, CGAH; Cerrinho

das Neves, Mértola, 29SPB1767, 2008.10.20, ÁDO, (2) sp, CGAH; Noudar Castle, Barrancos, 29SPC6927, 2008.10.19, ÁDO, (3) sp, CGAH; Mertola, G. Servain, 1 sh, MHNG 17059A, Lectotype, 10 sh, MHNG 17059B, Paralectotypes; Beira Alta: Sabugeiro, bases of low granite crags and walls near river, 1050 m, 29T 06149/44733, 2010.08.31, GAH and DTH – P71, 3 sh, CGAH; by N16 on W. edge of Gonçalbocas, granitic slopes with much bare rock, patchy herbs and grasses, bushes locally, 814 m, 29T 065385/449325, 2011.10.14, GAH and DTH – P209, (3) sp, 7 sh, not kept; W. edge of Moinhos de Aveia (W. of Alverca da Beira), rocky granitic slopes with patchy low scrub, 554 m, 29T 06518/45071, 2011.06.26, GAH – P165, 1 sh, not kept; Beira Baixa: *ca* 1.5 km W. of Lousa (S. of Vila de Rei), rocky (quarztite and slaty) slopes with patchy scrub and few trees, 210 m, 29S 05747/43862, 2011.07.27, GAH and DTH – P174, 1 sh, not kept; by Rio Zêzere and N238 ENE. of Dornes, rocky (slate) cuttings and slopes by road and reservoir, building ruins, 143 m, 29S 05644/44037, 2011.08.05, GAH and DTH – P177, (2) sp, 28 sh, CGAH; Barcoila, near Sertã, garden walls, *ca* 410 m, 29S 05741/44096, 2010.09.11, GAH – P72, (1) sp, 6 sh, CGAH; W. edge of Sertã, under cardboard on roadside verge with patchy herbs, *ca* 240 m, 29S 05769/44065, 2010.04.22, GAH – P37, (3) sp, 2 sh, CGAH; Rio Zêzere valley W. of Pedrógão Pequeno, rocky granitic slopes of valley side with open *Pinus* and *Quercus* woodland, *ca* 250 m, 29S 05737/44176, 2011.04.27, GAH and DTH – P140, (2) sp, CGAH; by Rio Ocreza and N241 E. of Vale da Mua, grassy banks near river, 29S 060554/439514, 2008.08.21, GAH – P6, 1 sh, not kept; Portas de Almorão, rocky (quartzite) slopes with patchy scrub and herbs, 275 m, 29S 060681/439902, 2010.12.19, GAH and DTH – P86, 15 sh, CGAH; *ca* 2 km W. of Vila Velha de Ródao, rocky (quartzite) ridge and slopes with patchy low scrub and herbs, 321 m, 29S 061177/439016, 2010.12.19, GAH and DTH – P87, 5 sh, CGAH; by N240 on W. bank of Rio Ponsul (W. of Ladoeiro), S.-facing rocky (sandstone) banks/cutting with patchy scrub and grasses, 183 m, 29S 064235/0441332, 2010.12.23, GAH and DTH – P88, (3) sp, 12 sh, CGAH; by N233 *ca* 3 km W. of Oledo, rocky (granite) slopes by road and river, with patches of trees and scrub, 260 m, 29S 06413/44263, 2011.01.15, GAH and DTH – P99, 1 sh, CGAH; by N353 just SE. of Idanha-a-Nova, rocky (granite) hillside with patches of scrub and low trees, 288 m, 29S 065144/442069, 2010.12.27, GAH and DTH – P95, (1) sp, 4 sh, CGAH; by N239 just SW. of Proença-a-Velha, rocky (granite) slopes by road and river, with patches of trees and scrub, 375 m, 29T 064964/443134, 2011.01.15, GAH and DTH – P100, (3) sp, 5 sh, CGAH; Beira Litoral: Casal de São Simao, NE. of Aguda, quartzite crags and slopes, grassland, walls of chapel, 385 m, 29S 05562/44188, 2011.09.06, GAH and DTH – P192, 5 sh, not kept; *ca* 2 km NE. of Favacal, quartzite rocks and slopes of hilltop, with grassland, bushes and concrete walls, 755 m, 29S 05576?44272, 2011.09.06, GAH and DTH – P191, (1) sp, not kept; *ca* 1 km N. of Pedrogão Grande, deciduous groves by stream, roadsides, rocky banks, walls, 330 m, 29S 057223/442063, 2011.08.11, GAH and DTH – P179, 3 sh, not kept; just S. of S. Pedro (S. of Figueira da Foz), coastal sand dunes with patchy low scrub, *ca* 10 m, 29T 05117/44412, 2011.01.13, GAH – P97, (3) sp, 11 sh, CGAH; Praia da Tocha, sand dunes with patches of low bushes, 14 m, 29T 05134/44647, 2010.11.18, GAH and DTH – P83, 2 sh, CGAH; *ca* 1 km NW. of Gafanha do Areão (SW. of Aveiro), sand dunes, with much *Acacia* scrub, 8 m, 29T 05188/44862, 2010.10.26, GAH – P76, (3) sp, 28 sh, CGAH; *ca* 1 km NW. of Verride near Rio Mondego, grassy banks with limestone boulders locally, 11 m, 29T 05244/44437, 2010.11.03, GAH and DTH – P78, 10 (4) sp, CGAH; just S. of Costa Nova do Prado, sand-dunes with patchy herbs and low shrubs, 7 m, 29T 05209/44948, 2011.05.03, GAH and DTH – P144, (3) sp, 4 sh, CGAH; Vista Alegre, Ílhavo, 29T NE2793, 2009.10.26, ÁDO, (1) sp, CGAH; N. of Ameal, grassland and limestone boulders on bank of river, *ca* 12 m, 29T 05393/44502, 2010.11.03, GAH and DTH – P80, 11 (4) sp, 12 sh, CGAH; Quinta das Lágrimas, Coimbra, 29TNE4849, 2010.05.11, ÁDO, (1) sp, CGAH; Botanical Garden, Coimbra, 29TNE4950, 2009.03.10, ÁDO, (3) sp, 1 sh, CGAH; Instituto Geofisico, Coimbra, 29TNE5051, 2009.11.20, ÁDO, (1) sp, CGAH;

Coja, Arganil, 29TNE8658, 2009.11.02, ÁDO, (1) sp, CGAH; S. Jacinto, Aveiro, 29TNF2303, 2008.08.30, ÁDO, (1) sp, CGAH; Cais do Puchadouro, Ovar, 29TNF3120, 2009.11.20, ÁDO, (1) sp, CGAH; Feira castle, Santa Maria da Feira, 29TNF3830, 2008.12.12, ÁDO, (3) sp, CGAH; Douro Litoral: just E. of São Félix da Marinha, walls and plantation with *Eucalyptus*, *ca* 105 m, 29T 05330/45424, 2007.05.20, GAH – 2007.17, 29 sh, CGAH; Botanical Garden, Porto, 29TNF3056, 2008.10.07, ÁDO, (3) sp, CGAH; Scarp over Douro River, Porto, 29TNF3354, 2008.01.14, ÁDO, (3) sp, CGAH; Estremadura: *ca* 1 km W. of Cela Velha (*ca* 6 km S. of Nazaré), roadsides, grassland and grove of *Populus*, *ca* 9 m, 29S 049419/437824, 2011.06.04, GAH and DTH – P164, 1 sh, not kept; just E. of lighthouse at Nazaré, sandy and gravelly coastal slope with short patchy vegetation, 52 m, 29S 049282/438393, 2010.12.25, GAH and DTH – P91, 3 sh, CGAH; S. Bartolomeu, 2 km SE. of Nazaré, granitic hill with crags, wooded slopes and old buildings, 155 m, 29S 04955/43825, 2011.06.04, GAH and DTH – P162, 7 sh, CGAH; just SW. of Vale de Parades, narrow strip of dune vegetation at base of cliff slope, 12 m, 29S 049561/439426, 2010.12.25, GAH and DTH – P92, 4 sh, CGAH; Pedras Negras, *ca* 3 km N. of S. Pedro de Moel, dunes with patchy low grasses and herbs, 20 m, 29S 049813/440313, 2010.08.12, GAH and DTH – P68, 1 sh, not kept; Serra da Arrábida, N.- to NW.-facing limestone crags and rocky slopes, 380 m, 29S 05021/42601, 2007.05.17, GAH – 2007.10, 5 sh, CGAH, mixed with *O. barbula*; Serra de Arrábida, N.- and S.-facing rocky limestone slopes with patches of scrub, 388 m, 29S 05020/42602, 2011.02.12, GAH and DTH – P129, 8 (5) sp, 3 sh, CGAH, mixed with *O. barbula*; Serra da Arrábida, S.-facing limestone crags and rocky slope, 300-350 m, 29S 05032/42604, 2007.05.17, GAH – 2007.11, 15 sh, CGAH; Serra de Arrábida, high on rocky S.-facing limestone slope with patchy low scrub, 351 m, 29S 05032/42604, 2011.02.12, GAH and DTH – P128, 20 (3) sp, 10 sh, CGAH; Lisbonne, G. Servain, 1 sh, MHNG 17060, from river floodline debris; Minho: Ofir (SE. of Esposende), low sand dunes with patchy bushes, herbs and grassland, 9 m, 29T05175/45972, 2011.08.30, GAH and DTH – P190, 2 sh, not kept; Valença fortress, Valença, 29TNG2953, 2009.04.08, ÁDO, (2) sp, CGAH; Monção fortress, Monção, 29TNG4258, 2009.01.30, ÁDO, (3) sp, CGAH; N. edge of Peneda village, rocky granitic slope with old walls, patchy grasses and herbs, 688 m, 29T 056447/464734, 2011.08.29, GAH and DTH – P187, (1) sp, not kept; *ca* 2 km N. of Lamas de Mouro, rocky mountain slope, facing S., sparse low vegetation, 1080-1100 m, 29T 05665/46570, 2011.08.29, GAH and DTH, 1 sh, not kept, old shell only; Trás-os-Montes: Penas Roias Castle, Mogadouro, 29TPF9685, 2009.11.10, ÁDO, (1) sp, CGAH; by IP2/N103-7 *ca* 2 km NNE. of Rabal, beside irrigation channels in *Fraxinus* grove with few *Quercus*, 618 m, 29T 06873/46388, 2011.06.29, GAH – P170, 2 sh, not kept; Bragança castle and Fervença River, Bragança, 29TPG 8630-8730, 2009.11.11, ÁDO, (3) sp, CGAH; by N218 *ca* 4 km due NW. of Vimioso, slopes of river gorge with crags (slate and schist), screes and patchy scrub, 447 m, 29T 070334/460939, 2011.06.30, GAH and DTH – P171, 2 sh, not kept; *ca* 1 km S. of Vale de Águia (NE. of Miranda do Douro), exposed low and flat granitic rocks with boulders, patchy scrub and low evergreen *Quercus* trees, 672 m, 29T 0729638/4600096, 2011.07.01, DTH – P172, (3) sp, not kept; Spain, Prov. Cáceres: by EX117 at Rio Salor, NE. of Membrio, slopes of slaty rock above river banks with patchy low vegetation, 159 m, 29S 067198/438245, 2010.12.23, GAH and DTH – E89, (1) sp, 4 sh, CGAH; by EX302 at Rio Salor, NE. of Herreruela, slopes of slaty rock above river banks with patchy low herbs and scrub, 209 m, 29S 068226/437263, 2010.12.23, GAH and DTH – E90, (2) sp, 1 sh, CGAH; Prov. La Coruña: E. edge of P. N. de Corrubedo, exposures of low granite rocks with moss locally and very sparse grasses, at edge of *Pinus* wood, 48 m, 29T 049808/471162, 2011.08.27, GAH and DTH – E183, 1 sh, not kept; Prov. León: by N536 *ca* 1 km S. of Salas de la Ribera, low roadside cutting, crag and scree of slaty rock with sparse low grasses and herbs (bushes above), 393 m, 29T 06796/46993, 2011.10.16, GAH and DTH – E213, 5 sh, not kept; NW. of Almázcara, low banks between grassland and road, above shallow ditch, with patchy grasses and herbs, bushes locally, 672 m, 29T

07035/47203, 2011.10.16, GAH and DTH – E212, 3 sh, not kept; Prov. Ourense: by OU533 0.5 km S. of Santa Cruz, low granitic rocks of road cutting with short patchy herbs and grasses, bushes locally, 621 m, 29T 065415/468485, 2011.10.17, GAH and DTH – E214, 2 sh, not kept; *ca* 1 km W. of San Tirso (Sierra de la Encina), N.-facing crags and slopes of hard limestone, *ca* 870 m, 29T 06701/47089, 2007.05.21, GAH – 2007.19, 1 sh, CGAH; by OU533 near Cemiterio *ca* 2 km S. of Santa Cruz, granitic rocks and slopes by road, with sparse herbs and few bushes, 648 m, 29T 065406/468446, 2011.10.17, GAH and DTH – E215, 5 sh, not kept; Prov. Pontevedra: la Lanzada (S. of O Grove), sand dunes with low vegetation, 8 m, 29T 05107/46992, 2011.08.26, GAH and DTH – E180, 2 sh, not kept; *ca* 3 km NW. of Sanxenxo, top of slaty sea-cliffs with low scrub and patches of grasses and herbs, *ca* 15 m, 29T 051032/469590, 2011.08.26, GAH and DTH – E181, (3) sp, CGAH; just NW. of San Vincente do Grove, open slopes above beach with blown sand over granite, patchy herbs and grasses, 15 m, 29T 050522/470284, 2011.08.27, GAH and DTH – E182, (2) sp, not kept; Prov. Zamora: by N631 at E. Nª Sª de Argavanzal (S. of Rionegro del Puente), slopes above reservoir edge with outcrops of metamorphic rock, patchy grassland, bushes and saplings, 797 m, 29T 072914/465153, 2011.10.17, GAH and DTH – E216, 2 sh, not kept.

O. barbula, Portugal, Beira Baixa: by IC8 just NE. of Ansião, woodland and grassland on limestone, 210 m, 29S 054915/441926, 2011.04.29, GAH and DTH – P141, (2) sp, CGAH; Beira Litoral: Serra de Sico (summit area), rocky limestone slopes with patchy low scrub and grassland, 548 m, 29S 053909/441909, 2011.01.13, GAH – P98, (3) sp, 10 sh, CGAH; Pombal Castle, 29SNE3218, 2008.04.24, ÁDO, 6 (3) sp, CGAH; *ca* 0.5 km S. of IC8 at *ca* 1.5 km WNW. of Ansião, limestone slopes with scrub, crags and grassland, *ca* 194 m, 29S 05466/44185, 2010.09.26, GAH and DTH – P73d, (1) sp, 23 sh, CGAH; 0.5 km S. of IC8 at *ca* 2 km WNW. of Ansião, rocky limestone slopes with scrub above, *ca* 190 m, 29S 054642/441843, 2010.09.26, GAH and DTH – P75, 2 sh, not kept; Vale da Couda (SE. of Almoster), limestone valley with low crags and patchy *Quercus* woodland, *ca* 263 m, 29S 05487/44103, 2010.05.29, GAH and DTH – P45, (1) sp, CGAH; *ca* 1.5 km W. of Ansião, low *Quercus* woodland on slope with limestone rocks, *ca* 239 m, 29S 05466/44179, 2010.09.26, GAH and DTH – P74, 3 sh, not kept; *ca* 1 km SW. of Ateanha village (E. of Alvorge), S.-facing limestone hillside with grassland, patchy scrub and rocks, 310 m, 29S 05498/44262, 2010.05.29, GAH and DTH – P46, (1) sp, CGAH; S. of IC8 at *ca* 3 km W. of Avelar, limestone slopes with short grasses and herbs, scrub locally, 288 m, 29S 05520/44192, 2011.02.24, GAH and DTH – P133, 9 sh, CGAH; *ca* 1 km SW. of Alfarelos, limestone crags and grassland, 13 m, 29T 05283/44439, 2010.11.03, GAH and DTH – P79, (4) sp, 8 sh, CGAH; by Paul do Taipal near Montemor-o-Velho, disused limestone quarry with patches of short vegetation, 45 m, 29T 05271/44481, 2011.01.09, GAH – P96, (3) sp, 6 sh, CGAH; by Ruinas de Conimbriga, open *Olea* grove with grassland and herbs beneath, *ca* 100 m, 29T 054352/443878, 2010.04.27, GAH and DTH – P39, 1 sh, CGAH, old shell only; Conimbriga, Condeixa-a-Nova, 29TNE4339, 2008.10.26, ÁDO, (3) sp, CGAH; by Rio de Mouros, S. of Condeixa-a-Velha, deciduous woodland with rocky limestone banks beside stream, *ca* 117 m, 29T 05436/44386, 2010.04.27, GAH and DTH – P38, 2 sh, CGAH; Castelo do Rabaçal, rocky limestone slopes, grassland and scrub, *ca* 315 m, 29T 05489/44309, 2010.04.27, GAH and DTH – P40, 1 sh, CGAH; Penela Castle, 29TNE5231, 2008.10.13, ÁDO, (2) sp, CGAH; Estremadura: Serra da Arrábida, limestone crags and rocky slopes (S.-facing), 250 m, 29S 04999/42576, 2007.05.16 and 18, GAH – 2007.9 and 15, 68 sh, CGAH; Serra de Arrábida, rocky limestone slope and road cutting facing S. and E., with patchy scrub, 263 m, 29S 05000/42577, 2011.02.12, GAH and DTH – P130, 4 (3) sp, 9 sh, CGAH; Serra de Arrábida, herbs and grasses at base of S.-facing limestone road cutting, 131 m, 29S 050117/425874, 2011.02.12, GAH and DTH – P131, (1) sp, 12 sh, CGAH; Serra da Arrábida, N.- to NW.-facing limestone

crags and rocky slopes, 380 m, 29S 05021/42601, 2007.05.17, GAH – 2007.10, 12 sh, CGAH, mixed with *O. barbella*; Serra de Arrábida, N.- and S.-facing rocky limestone slopes with patches of scrub, 388 m, 29S 05020/42602, 2011.02.12, GAH and DTH – P129, 4 sp, 6 sh, CGAH, mixed with *O. barbella*; Serra de Montejunto, rocky limestone slopes and crags with low scrub and varied herbs, *ca* 400 m, 29S 04950/43382, 2010.04.19, GAH – P34, 2 sh, not kept; *ca* 2.3 km NE. of São Pedro de Moel, crevices amongst limestone boulders at base of wall of road bridge by stream, 35 m, 29S 049877/440268, 2010.08.12, GAH and DTH – P67, (3) sp, 12 sh, CGAH, atypical shells (see text); *ca* 2 km NNE. of São Pedro de Moel, bank 2 m above stream in *Eucalyptus* woodland on coastal sands, 20 m, 29S 049872/440265, 2011.06.04, GAH and DTH – P161, (4) sp, 4 sh, CGAH, atypical shells (see text); Fórnea (SE. of Alcaria), limestone crags, screes and slopes, patchy scrub, *ca* 275 m, 29S 05170/43789, 2010.05.02, GAH and DTH – P43, 10 sh, CGAH; *ca* 1 km SW. of Serro Ventoso, rocky limestone slopes and road cutting, scrub and wooded slopes, *ca* 380 m, 29S 05140/43784, 2010.07.19, GAH and DTH – P59, 13 sh, CGAH; Serro Ventoso, Porto de Mós, 29SND1479, 2008.02.12, ÁDO, 3 (2) sp, CGAH; *ca* 2 km NW. of Serro Ventoso, rocky limestone slope with low crags and scrub, 29S 05129/43809, 2010.07.30, GAH – P62, 9 sh, CGAH; valley 0.5 km E. of Livramento, limestone valley with patchy scrub and low rocks, 174 m, 29S 05168/43814, 2010.08.06, GAH and DTH – P65, 21 sh, CGAH; *ca* 1.5 km SE. of Livramento, rocky limestone slopes facing E. below crag, with evergreen *Quercus* woodland, 290 m, 29S 05170/43806, 2010.08.06, GAH and DTH – P64, 19 sh, CGAH; *ca* 0.5 km SE. of Livramento, rocky limestone slope with grassland and scrub, 238 m, 29S 05170/43809, 2011.03.22, GAH – P136, 2 sh, not kept; Ribatejo: SE. of Moitas Venda, limestone crags and rocky slopes with scrub, *ca* 195 m, 29S 05311/43717, 2010.05.02, GAH and DTH – P41, (2) sp, 27 sh, CGAH; Convento de Cristo, just W. of Tomar, convent and castle walls and ruins, old gardens, 126 m, 29S 05499/43839, 2011.08.05, GAH and DTH – P175, 6 sh, not kept; *ca* 2 km NNE. of Santa Cita, river banks with mature trees, dumped masonry, *Ulmus* grove, roadside verge and grassy banks, 65 m, 29S 05526/43795, 2011.08.05, GAH and DTH – P176, 9 (4) sp, CGAH; locality unknown: leg. Holl, 1 sh, SMF 7035, Paralectotype, 1 sh, SMF 7036, Lectotype.

A revision of the Mediterranean Raphitomidae 1: on the sibling species *Raphitoma contigua* Monterosato, 1884 and *Raphitoma spadiana* n. sp. (Gastropoda, Conoidea)

Revisión de los Raphitomidae del Mediteráneo 1: las especies hermanas *Raphitoma contigua* Monterosato, 1884 y *Raphitoma spadiana* n. sp. (Gastropoda, Conoidea)

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ABSTRACT

A new raphitomid toxoglossan, *Raphitoma spadiana* n. sp., is described from the Mediterranean Sea. It is the sister species to *R. contigua* Monterosato, 1884, from which it differs in the different protoconch (paucispiral vs. multispiral), adding to a long list of pairs of caenogastropod species differing in their larval development.

RESUMEN

Una nueva especie de toxogloso rafitómido, *Raphitoma spadiana* n. sp., se describe del Mediterraneo. Es especie hermana de *R. contigua* Monterosato, 1884, de la cual se diferencia por su protoconcha (pauciespiral vs. multiespiral), y se añade a una larga lista de parejas de especies que difieren en su desarrollo larvario (planctotrofico vs. no-planctotrofico).

INTRODUCTION

The superfamily Conoidea, with over 300 genera and 4.000 recognised species, but probably over 12,000 extant species (Bouchet, 1990; Taylor, Kantor & Sysoev, 1993; Tucker, 2004), represents the largest radiation of the entire phylum Mollusca. In a work on the phylogeny of the group based on a cladistic analysis of foregut morphology, Taylor *et al.* (1993) have highlighted the rampant homoplasy in the characters of shell and radula in conoideans. Accordingly, they have rearranged most of the conoideans into two families: Conidae, comprising Coninae and 4 subfamilies traditionally considered as 'turrids', and Turridae s.s. including some of the traditional 'turrids'. More recently, Puillandre, Samadi, Boisselier, Sysoev, Kantor, Cruaud, Couloux & Bouchet (2008) and Bouchet, Kantor, Sysoev & Puillandre (2011), based on DNA phylogeny, have provided a major update of conoidean classification. Although a larger taxonomic coverage would be desirable to further stabilize the molecular phylogeny, however, the position of

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the Raphitomidae as a clade of the Conoidea is sufficiently supported.

Raphitomidae are based on the genus *Raphitoma*, which was introduced by BELLARDI, (1847: 85), as including 34 fossil and extant species. During the revision of the Mediterranean Raphitomidae we are currently carrying out, we have found several pairs of species, differing only or mostly in the size and shape of the protoconch. After the pioneer works of THORSON (1946, 1950), addressing the relationships between protoconch morphology and type of larval development in the caenogastropods, the dichotomy multispiral protoconch/planktrotrophic development vs. paucispiral protoconch/ lecithotrophic development has been largely accepted (JABLONSKI & LUTZ, 1980; REX & WARÉN, 1982). Although some authors have used this dichotomy to allocate species into planktotrophic vs. non-planktotrophic genera (e.g.: POWELL, 1966; AARTSEN 1988), BOUCHET (1990) has clearly demonstrated that such abuse of protoconch morphology would produce polyphyletic taxa, and artificially separate closely related species among distinct genera. In raphitomids, the separation of *Raphitoma* (multispiral protoconch) and *Philbertia* (paucispiral protoconch) is inconsistent and must be rejected.

On the other hand, differences in protoconch morphology, which reflect differences in larval development (planktotrophic vs. lecithotrophic) are a good base to recognise distinct species in caenogastropods. In fact, poecilogony (the ability of a species to use different developmental strategies, e.g. planktotrophy and lecithotrophy) is not observed within the prosobranchs (BOUCHET, 1989), whilst it has been sometimes recorded among opisthobranchs [e.g.: *Haminoea callidegenita* Gibson & Chia, 1989, *Elysia chlorotica* Gould, 1870, *Alderia willowi* Krug, Ellingson, Burton & Valdés, 2007 (WEST, HARRIGAN & PIERCE 1984, GIBSON & CHIA, 1995, KRUG, ELLINGSON, BURTON & VALDÉS, 2007)].

The presence of pairs of caenogastropod species with multispiral vs. paucispiral protoconchs has been particularly reviewed in the Mediterranean Sea (see OLIVERIO, 1996a, b, with references therein), but it is a phenomenon observed on a global scale (OLIVERIO, 1997). It has been related to a speciation model, where the very shift in larval development with loss of planktotrophy has been the driving mechanism of speciation (OLIVERIO 1996a).

In the genus *Raphitoma*, we have scored several such pairs of species with different protoconchs (multispiral vs. paucispiral). A thorough revision of all Mediterranean pairs (which we have currently in progress) will be the subject of a forthcoming paper. In the present work we present the case of the rather obscure taxon *Raphitoma contigua* (Monterosato, 1884), of which we have examined the type material and selected a lectotype with multispiral protoconch to stabilize the usage of the name, and its unnamed sister species with paucispiral protoconch.

Abbreviations:

HUJ = Hebrew University of Jerusalem (Israel)
MCZR = Museo Civico di Zoologia di Roma (Italy)
MNHN = Muséum National d'Histoire Naturelle (Paris, France)
NMW = National Museum of Wales (Cardiff, United Kingdom)
SMNH = Swedish Museum of Natural History (Stockholm, Sweden)
sh = shell(s)

SYSTEMATICS

(Citation of unpublished names is not intended for taxonomic purposes)

Family RAPHITOMIDAE Bellardi, 1875

Genus *Raphitoma* Bellardi, 1847

Type species: *Pleurotoma hystrix* Cristofori and Jan, 1832 (*nomen nudum*, validated by Bellardi, 1847 as "*Pleurotoma histrix* Jan") by subsequent designation (Monterosato, 1872: 16).

Synonyms:
Homotoma Bellardi, 1875 non Guérin-Ménéville, 1844 – type species: *Murex textile* Brocchi, 1814 by subsequent designation (Fischer, 1883).
Cirillia Monterosato, 1884, non Rondani, 1856 – type species: *Murex linearis* Montagu, 1803, by subsequent designation (Crosse, 1885).
Cordieria Monterosato, 1884 non Roualt, 1848 – type species: *Murex reticulatus* Brochi, 1814, by subsequent designation (Crosse, 1885).
Leufroyia Monterosato, 1884 – Type species: *Pleurotoma leufroyi* Michaud, 1827, by subsequent designation (Crosse, 1885)
Philbertia Monterosato, 1884 – type species: *Pleurotoma philberti* Michaud, 1829 by subsequent designation (Crosse, 1885)
Peratoma Harris & Burrows, 1891 – nomen novum pro *Homotoma* Bellardi, 1875, non Guérin Ménéville, 1844
Cenodagreutes E.H. Smith, 1967 – type species: *Cenodagreutes aethus* E. H. Smith, 1967, by original designation.
Cyrtoides Nordsieck, 1968 – type species: *Pleurotoma rudis* Scacchi, 1836, by original designation.
Lineotoma Nordsieck, 1977 – nomen novum pro *Cirillia* Monterosato, 1884, non Rondani, 1856

Diagnosis: Shell of small to medium-small size (5-25 mm), turreted, fusiform or ovoid-fusiform, with slender spire and uniformly convex whorls. Reticulate-cancellate sculpture on the teleoconch. Protoconch of 3-4 whorls when multispiral, with a protoconch I (embryonic shell) of 0.5-0.7 whorl and a protoconch II (larval shell) of 2-3 whorls, with a diagonally cancellate sculpture. Paucispiral protoconch of 2 whorls, with large nucleus and reticulate sculpture.

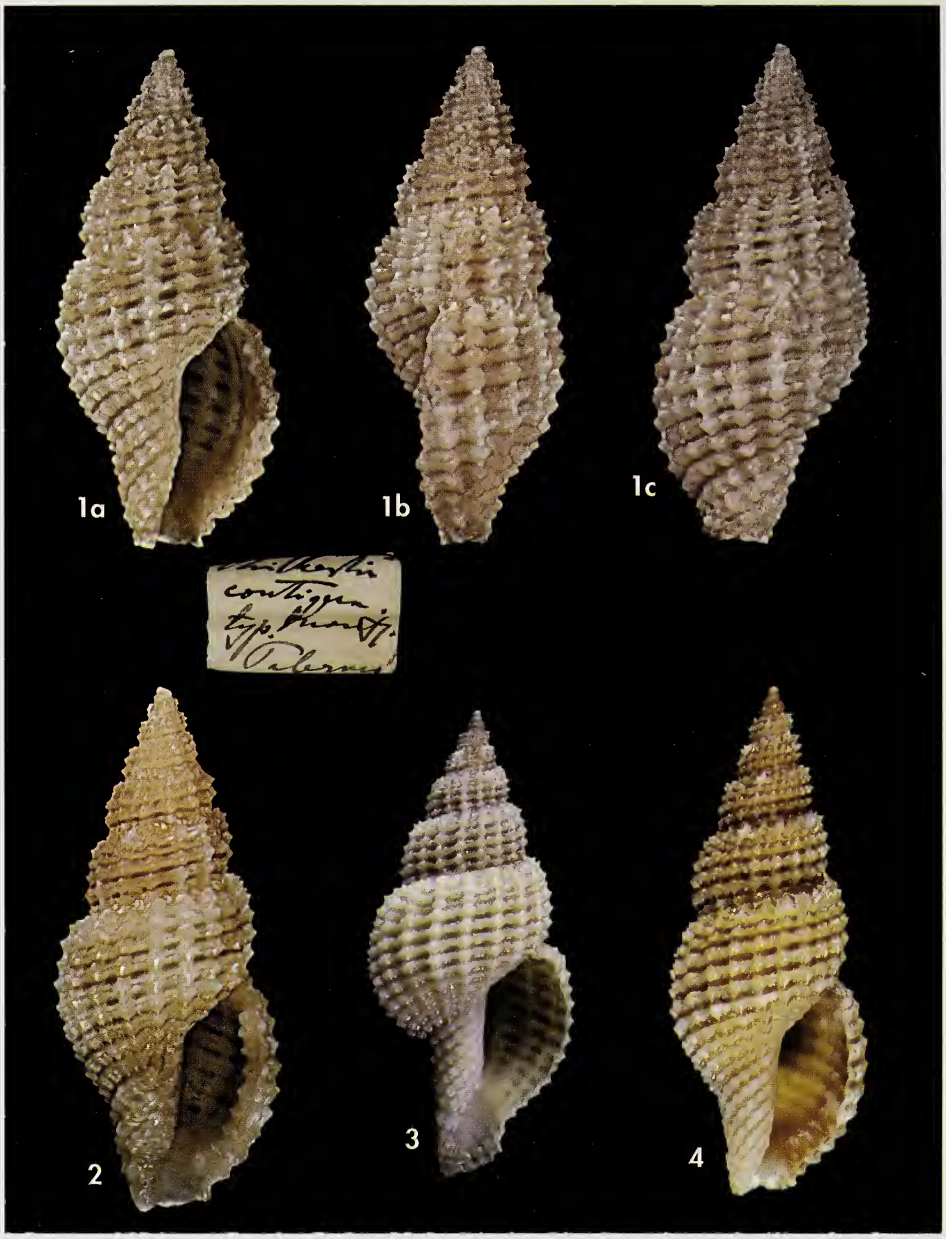
Remarks: For the complex nomenclatural issues, including the type species designations, see DALL (1918), VAN AARTSEN, MENKHORST & GITTENBERGER (1984: 89-90) and ROLÁN, OTERO-SCHMITT & FERNANDES (1998: 105).

In the Mediterranean Sea, species of *Raphitoma* are usually found alive on soft bottoms, ranging from coastal bioclastic sands to muddy bioclastic sands (DC and DE, respectively: PÉRÈS & PICARD, 1964) although it is not infrequent to find specimens hiding under stones and in crevices, especially at daytime.

Raphitoma contigua (Monterosato, 1884) (Figs. 1-3, 14)

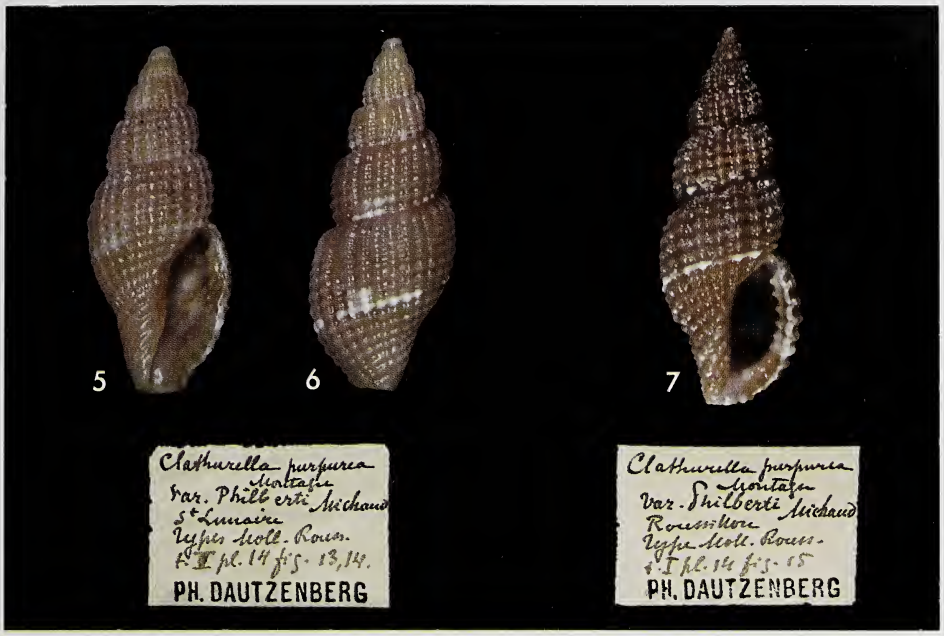
Philbertia contigua Monterosato, 1884:133

Type material: Lectotype (here designated, 9.05 x 4.16 mm) and one paralectotype (9.30 x 4.10 mm) with handwritten label by Monterosato: "Ph. contigua typ. Monts! Palermo" (MCZR, 16702/1); 3 paralectotypes with handwritten labels by Monterosato: "Ph. contigua Monts. / Napoli Staz. Zool." (MCZR, 16702/2); 2 paralectotypes labelled "contigua Napoli" (MCZR, 16702/3); 3 paralectotypes with handwritten labels by Monterosato: "R. contigua – Isole Baleari" (MCZR, 16702/4); 16 paralectotypes with handwritten label by Monterosato "Ph. contigua M. / Pal!", coll. Coen in HUJ, 8072 (including 7 specimens of *R. bicolor*); 2 paralectotypes with handwritten Dautzenberg label: "Clathurella purpurea/Montagu/var. Philberti Michaud/St Lunaire/Types Moll. Rouss./ t. I pl. 14 fig. 13,14" (two specimens of *R. oblonga*) (MNHN, Paris); 1 paralectotype with handwritten Dautzenberg label: "Clathurella purpurea/Montagu/var. Philberti Michaud/Roussillon/Type Moll. Rouss./ t. I pl. 14 fig. 15" (a specimen of *R. atropurpurea*) (MNHN, Paris). Type locality: Palermo.



Figures 1-4. Shells of *Raphitoma* spp. 1-3. *Raphitoma contigua* (Monterosato, 1884). 1a-c: lectotype (MCZR, 16702/1, h: 9.05 mm) with original label; 2: Ficarazzi, Palermo (coll. Pusateri, h: 10 mm); 3: Roquebrune, Les Issambres (coll. Hoarau, h: 9.7 mm), subadult shell with 8 spiral cordlets above the aperture. 4. *Raphitoma lineolata* B.D.D., 1884, St. Raphaël, France (coll. Hoarau, h: 7.2 mm).

Figuras 1-4. Conchas de Raphitoma *spp. 1-3.* Raphitoma contigua *(Monterosato, 1884). 1a-c: lectotipo (MCZR, 16702 / 1, h: 9,05 mm) con la etiqueta original; 2: Ficarazzi, Palermo (col. Pusateri, h: 10 mm); 3: Roquebrune, Les Issambres (col. Hoarau, h: 9,7 mm), concha subadulto con 8 cordoncillos espirales encima de la abertura. 4.* Raphitoma lineolata *B.D.D., 1884, Saint Raphaël, Francia (col. Hoarau, h: 7,2 mm).*



Figures 5-7. Shells of *Raphitoma* spp. figured in Bucquoy, Dautzenberg & Dollfus (1883), labelled as "*Clathurella purpurea* var. *philberti* Michaud". 5, 6: *Raphitoma oblonga* (Jeffreys, 1867), St. Lunaire (BDD, 1883: pl. 14, figs 13, 14) with original label (MNHN, Paris); 7: *Raphitoma atropurpurea* (Locard & Caziot, 1899), Roussillon (BDD, 1883: pl. 14 fig. 15) with original label (MNHN, Paris).

Figuras 5-7. Conchas de Raphitoma *spp. figuradas en Bucquoy, Dautzenberg y Dollfus (1883), etiquetadas como* "Clathurella purpurea *var.* philberti *Michaud". 5, 6:* Raphitoma oblonga *(Jeffreys, 1867), Saint Lunaire (BDD, 1883: lám. 14, fig. 13, 14) con la etiqueta original (MNHN, París); 7:* Raphitoma atropurpurea *(Locard y Caziot, 1899), Rosellón (BDD, 1883: lám. 14, fig. 15) con la etiqueta original (MNHN, París).*

Material examined: The type material and: France – Marseille (MCZR, coll. Monterosato, inv. 16811, 4 sh.: labelled by Monterosato "*H. conformis*", an unpublished manuscript name). Roquebrune, Les Issambres (Var), (coll. Hoarau, 1 sh.). St. Raphael, Cote d'Azur (MCZR, coll. Monterosato, 16696, 1 sh.: labelled "*P. tomentosa*"). Corsica – Bastia (coll. Pusateri, 1 sh.; coll. Margelli, 1 sh.). Bastia, Alistro (coll. Margelli, 2 sh.). Sardinia – Ennio Falco Cave, Porto Conte, Sassari (coll. Oliverio, 3 sh.). La Maddalena Is. (coll. Rufini, 1 sh.; coll. Spanu, 1 sh.). Oristano, (coll. Rufini, 2 sh.). S'Archittu, Oristano (coll. Sossu, 2 sh.). Stintino, Sassari (coll. Rufini, 1 sh.). Torre del Bollo, Alghero (coll. Spanu, 1 es.). Liguria – Genova (coll. Pusateri 2 sh.). Tuscany – Calambrone (Pisa), coll. Bartolini, 1 sh. Castiglioncello, Livorno (coll. Coppini, 1 sh.), (coll. Margelli, 2 sh.). Punta Ala, Grosseto (coll. Coppini, 1 sh.). Giannutri Is. (coll. Smriglio, 1 sh). Elba Is., Marina di Campo (coll. Bartolini, 7 sh.). Elba Is. (coll. Bartolini, 4 sh.). Tuscan Archipelago (coll. Bartolini, 4 sh.). Latium – Tor Paterno Marine Protected Area, Roma (coll. Oliverio, 1 sh.), (coll. Rufini ex Ruggeri, 1 sh.). Campania – Trombetta Cave, -35 m, Palinuro, Salerno (coll. Oliverio, 1 sh.). Punta Campanella, Napoli (coll. Bartolini, 2 sh.). Sicily – Acitrezza, Catania (SMNH, lot 73198F, 10 sh.). Cannizzaro, Catania (coll. Micali, 3 sh.). Palermo (coll. Pusateri, 18 sh., 1 albinistic). Palermo (HUJ, In. 8080 with Coen's label *Philbertia purpurea lineolata* BDD, 1 sh). Aspra, Palermo (coll. Girgenti, 3 sh.). Isola delle Femmine, Palermo (coll. Pusateri, 3 sh. legit Bagnera). Palermo (MCZR, coll. Monterosato, inv. N, 16702, 2 sh.). Gulf of Carini, Palermo (coll. Palmeri, 3 sh.). Capo Passero (coll. Margelli, 1 sh.). Taormina, Messina (coll. Villari, 1 sh.). Pantelleria Is. (coll. Bartolini, 1 sh.). Apulia – Taranto (MCZR, coll. Monterosato, *sine numero*

3 sh.). Croazia – Korcula Is. (coll. Micali, 1 sh.). Krk Is. (coll. Bartolini, 10+ sh.). Velirat, Dugi Otok (Isola Lunga) (coll. Pusateri, 1 sh.). Algeria – Algiers (MCZR, coll. Monterosato, 16815, 1 sh). "C. d'Afr." [Coasts of Africa], (MCZR, coll. Monterosato, unnumbered lot, *sine nomine*, 4 sh.).

Description: Shell sub-fusiform (mean h/d 2.2, std 0.13), height 9-15 mm (mean 10.9, std 1.70), width 4.5-6 mm (mean 4.9, std 0.49). Protoconch multispiral of 2.7 convex whorls, height 325 µm, width 300 µm; protoconch I of 0.6 whorls, width 170 µm, with irregularly placed small tubercles; protoconch II of 2.1 whorls, with a diagonally cancellate sculpture, and two suprasutural small spiral threads.

Teleoconch of 7 convex whorls. Axial sculpture of 16-18 orthocline or slightly opisthocline ribs (sometimes more in larger specimens), and interspaces wider (×1.5) than the ribs. Spiral sculpture on the last whorl of 17-20 cordlets, of which 6-7 (rarely 8) above the aperture, slightly narrower than the axial ribs. Cancellation rectangular, with small and elongated tubercles at the intersection of axials and spirals. Tubercles on the two adapical cordlets narrow and spinulose (especially in fresh or subadult specimens). Sculpture visible in transparency throughout the internal shell wall.

Subsutural ramp narrow, with small tubercles in correspondence with the axial ribs tip.

Columella simple, slightly sinuous anteriorly, gently angled posteriorly. Outer lip with 8-9 strong inner denticles (rarely 10-11), the most anterior delimiting the siphonal canal, the most posterior delimiting the anal sinus.

Colour uniformly tawny, rarely darker, sometimes with lighter spots. Suprasutural cordlet occasionally white. Occasional comma-shaped white spots on the subsutural ramp.

Distribution: Only known from examined material, probably the entire Mediterranean Sea.

Remarks: Monterosato (1884: 133) introduced *Philbertia contigua* without any description, but with reference to BDD (1883) as follows:

"*P. contigua*, Monts. (nov. forma)

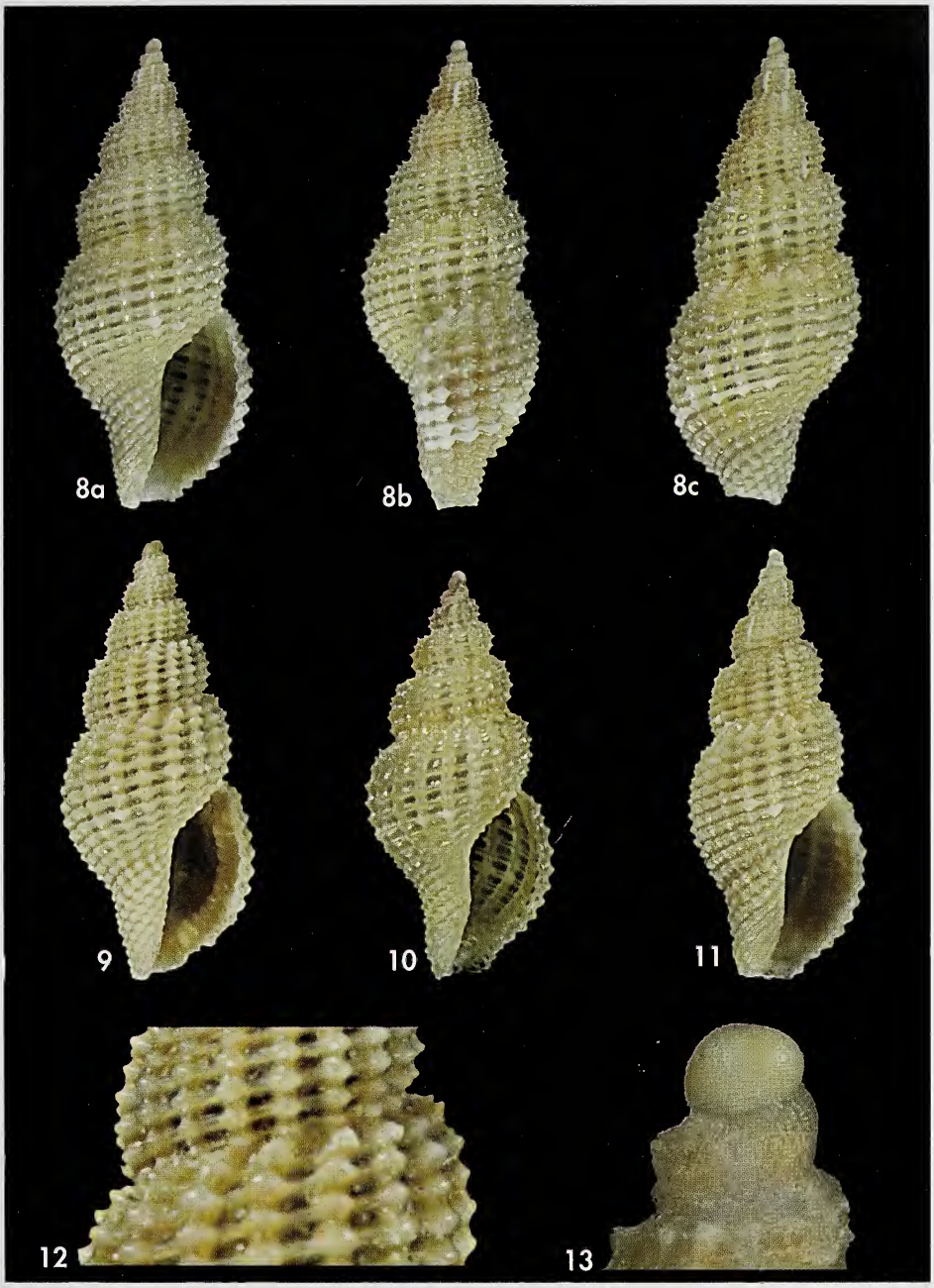
= *Clathurella purpurea* (non Mtg.) var. *Philberti* (non Mich.), B.,D. e D. – l.c. [Moll. Mar. Roussillon] p. 40, t. 14, f. 13-15 (C. di Prov.).

=? *Anna Massena* Risso – 1826, p. 214, f. 68 (foss. Alpi Marit.),

Isole Baleari (Monjò); Alger (Joly); Bona (Hagenmüller); Palermo e Messina (Monts.); Napoli, Lipari (Tiberi) ecc."

Evidently, Monterosato did not check *de visu* the original material used for BDD's plates (now stored at MNHN, Paris: Figs. 5-7), relying only on BDD's figures. In fact, Monterosato cites "C.[oste] di Prov.[enza]" (coasts of Provence), evidently presuming that the figured specimens were all from Provence. Actually, the specimens in BDD's figs 13 and 14 (MNHN, Paris) are labelled as coming from St. Lunaire (Bretagne), and only the shell of fig. 15 is from Roussillon. However, the lots in the Monterosato collection labelled as *Philbertia contigua* are not conspecific with the specimens figured in BDD's figs 13-14 (Figs 5, 6), which are referable to *Raphitoma oblonga* (Jeffreys, 1867) a valid species from the Channel area, nor with the specimen figured in BDD's fig. 15 (Fig. 7), which is referable to *Raphitoma atropurpurea* (Locard & Caziot, 1899). Monterosato's concept of *contigua* remained constant, as we have verified in several collections hosting specimens ex Monterosato (Melvill-Tomlin, National Museum of Wales, lot 12908; Coen, Hebrew University, lot 8072). Evidently, also Dautzenberg & Durouchoux, 1900: 14 and Locard & Caziot, 1899:58, while citing *R. contigua* realized that the material sent to them by Monterosato did not fit BDD's figures 13-14, and kept *contigua* as a distinct entity. Nevertheless this does not invalidate that the specific name *contigua* is made nomenclaturally available "by indication" (ICZN art. 12.2), with a type material that includes all the localities cited in Monterosato (1884).

R. contigua (h/d 2.2) is less slender than the most similar species with multispiral protoconch: *R. lineolata* (BDD,



Figures 8-13. Shells of *Raphitoma spadiana* spec. nov. 8a-c: holotype, Lipari Is. (MNHN, h: 9.6 mm); 9, 12: paratype A, Lipari Is. (MNHN, Paris, ex coll. Pusateri h: 8 mm); 10: North African coasts, "C.[oste] d'Afr.[ica]" (MCZR, coll. Monterosato, unnumbered lot, h: 6.8 mm); 11, 13: La Ciotat, France (MCZR, 16773, coll. Monterosato, *sine nomine,* h: 8.6 mm).

Figuras 8-13. Conchas de Raphitoma spadiana *spec. nov. 8a-c: holotipo, islas Lipari (MNHN, h: 9,6 mm); 9, 12: paratipo, islas Lipari (MNHN, París, ex coll Pusateri h: 8 mm); 10: costas de África del Norte "C.[oste] d'Afr.[ica]." (MCZR, coll Monterosato, lote sin número, h: 6,8 mm); 11, 13: La Ciotat, Francia (MCZR, 16773, col Monterosato, sine nomine, H: 8,6 mm).*

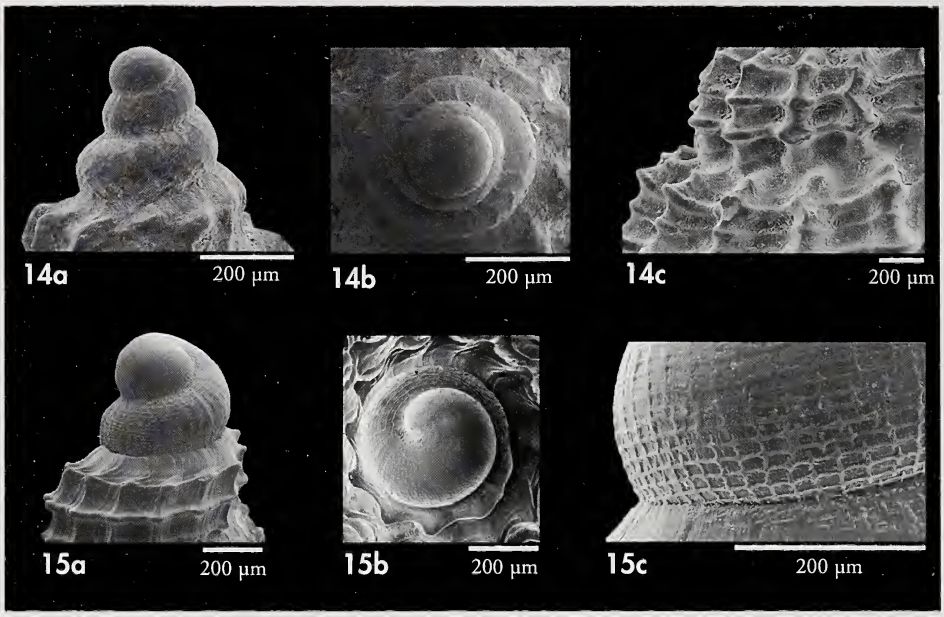
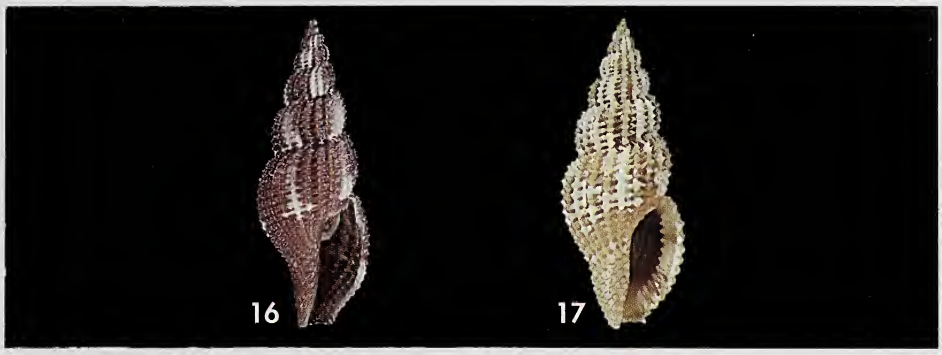


Figure 14. *Raphitoma contigua* (Monterosato, 1884). 14a,b: protoconch; 14c: subsutural ramp. Figure 15a-c. Protoconch of *Raphitoma spadiana* n. sp.
Figura 14. Raphitoma contigua *(Monterosato, 1884). 14a,b: protoconcha; 14c: rampa subsutural. Figura 15a-c. Protoconcha de* Raphitoma spadiana *n. sp.*

1882) (h/d 2.8), *R. atropurpurea* (Locard & Caziot, 1899) (h/d 2.8), *R. densa* (Monterosato, 1884) (h/d 2.8), *R. oblonga* (Jeffreys, 1867) (h/d 2.5). *Raphitoma lineolata* (Fig. 4) is very similar in general aspect, but has a less robust shell, lacks the narrow subsutural ramp, has a narrower aperture, and shows always few and scattered white tubercles on the last whorl as well as a subsutural white cord, both lacking in *contigua*. *R. atropurpurea* has a different colour (dark brown-purplish vs. tawny). *R. densa* (Fig. 17) is more densely sculptured, and has a colour pattern of ash-grey spots over a dark chestnut background. *R. oblonga* is a less known, exclusively Atlantic species, differing from *R. contigua* by its narrower aperture and the constant presence of a white spiral line as long as the space of four axial ribs, starting on the outer lip.

R. alternans (Monterosato, 1884) (see Fig. 16) has a paucispiral protoconch, and differs also from *R. contigua* in being more slender (h/d 2.6 vs. 2.2), and in its colour pattern of white spots over a dark chestnut background.

Shells with identical teleoconchs of the *contigua* type, but with two distinct protoconch types (multispiral vs. paucispiral) are known, and we consider them as distinct species. Therefore, we have examined the protoconchs in the type material of *Philbertia contigua* Monterosato, which turned out to consist as follows: MCZR 16702/1, one shell has a multispiral protoconch, the other lacks protoconch; MCZR 16702/2, one lacks protoconch, two with parts of multispiral protoconch; MCZR 16702/3, both with parts of multispiral protoconch; MCZR 16702/4, with parts of multispiral protoconch. To stabilize the use of the name *R. contigua* we have selected the shell in the lot MCZR, 16702/1 with intact (multispiral) protoconch, as the lectotype of *Philbertia contigua* Monterosato.



Figures 16, 17. Shells of *Raphitoma* spp. 16: *Raphitoma alternans* (Monterosato, 1884), syntype (MCZR, 16676, h: 12.00 mm), Mondello (Palermo); 17: *Raphitoma densa* (Monterosato, 1884), syntype (MCZR, 16807, h: 10.15 mm), Palermo.
Figuras 16, 17. Conchas de Raphitoma *spp. 16:* Raphitoma alternans *(Monterosato, 1884), sintipo (MCZR, 16676, h: 12,00 mm), Mondello (Palermo); 17:* Raphitoma densa *(Monterosato, 1884), sintipo (MCZR, 16807, h: 10,15 mm), Palermo.*

Raphitoma spadiana Pusateri & Giannuzzi-Savelli spec. nov. (Figs. 8-13, 15)

Type material: Holotype (MNHN, Paris) height 9.6 mm, width 4.1 mm, from Lipari Is. (Sicily) (legit Claudio Ebreo). Paratype A (coll. Pusateri, height 8.0 mm, width 3.7), from Lipari Is.; Paratype B (MNHN, Paris) height 8.1 mm, width 3.6 mm, from Scilla, Calabria, -50 m (legit Angelo Vazzana)
Other material examined: France – Marseille (coll. Locard, MNHN Paris, 1 shell). La Ciotat, Cote d'Azur (coll. Monterosato, MCZR, 16773, *sine nomine* 8.6 x 3.8 mm). Sardinia – Alghero (coll. Spanu, 1 sh. juv.). Calabria – Scilla, Reggio Calabria (coll. Vazzana, 20 shells). Sicily – Mondello (Palermo) (coll. Pusateri, 2 shells, juv.). Marettimo Is. (coll. Agamennone 1 shell, juv.). Marettimo Isl. (coll. Agamennone, 1 sh.). Apulia – Taranto (coll. Giannuzzi Savelli, 1 shell). Egypt – Alexandria (coll. Pusateri, legit Claudio Ebreo, 2 shells). Tunisia – Djerba Is., (coll. Agamennone, 1 shell). "C. d'Afr." [Coasts of Africa], (MCZR, coll. Monterosato, unnumbered lot, *sine nomine* 1 sh. subadult, height 6.8 mm, width 3.2 mm; stored with 4 shells of *R. contigua*). Greece – Crete Is. (coll. Alfinito, 1 shell). Cyprus – (coll. Bartolini, 1 sh.)
Etymology: after our dear friend Gianni Spada, a specialist of turrid taxonomy.
Type locality: Lipari Is.

Description: Shell subfusiform 9.5 mm high and 4.1 mm wide.

Protoconch paucispiral, only protoconch I of 1.25 convex whorls, height 425 µm, width 450 µm; sculpture irregularly cancellate.

Teleoconch of 6 convex whorls. Axial sculpture of 18 orthocline ribs, interspaces wider (×1.5) than the ribs.

Spiral sculpture on the last whorl of 23 cordlets, of which 8 above the aperture, slightly narrower than the axial ribs, interspaces wider (×2) than the ribs. Cancellation rectangular, with small and elongated tubercles at the intersection of axials and spirals. Tubercles on the two subsutural cordlets narrow and spinulose. Sculpture visible in transparency throughout the very thin internal shell wall.

Subsutural ramp narrow, with small tubercles in correspondence with the tip of the axial ribs. Two cordlets on the subsutural ramp, the adapical smaller with smaller tubercles, the second being the largest of the spirals. The third cordlet, as small as the first one.

Columella simple, slightly sinuous anteriorly, gently angled posteriorly. Outer lip with 12 strong inner denticles, the most anterior delimiting the siphonal canal, the most posterior delimiting the anal sinus. Denticles 1-2 and 11-12 closer than the others.

Siphonal canal short, open.

Colour uniform light tawny, with rare lighter tubercles. Some axial ribs entirely white on the first three teleoconch whorls; on the last whorl tenth spiral cordlet and last two axial ribs partly white.

Distribution: Only known from examined material, probably entire Mediterranean Sea.

Remarks: Variation of the examined material: height 6.8-11.7 mm (mean 9.4 std 1.76), width 3.2-4.6 mm (mean 4.1 std 0.56); mean h/d: 2.3 std 0.15.

Axial ribs 16-18, sometimes slightly opisthocline in the last whorl. Occasional comma-shaped white spots on the subsutural ramp. Colour ranging from light to very light tawny. White axial ribs from present in all whorls to very rare or absent. The spiral cordlet 10 may be white spotted.

Raphitoma spadiana differs from the closely related *R. contigua* in its paucispiral protoconch and thus an inferred lecithotrophic development (vs. multispiral protoconch and an inferred planktrotrophic development in *contigua*). Additionally, *R. spadiana* is of slightly smaller size, and lighter in colour. *R. alternans* (Monterosato, 1884) has also a paucispiral protoconch, but differs also from *R. spadiana* by being more slender (h/d 2.6 vs. 2.3), and by its colour pattern of irregular white spots over a dark chestnut background.

R. spadiana (h/d 2.3) is also less slender than the most similar species with multispiral protoconch: *R. lineolata* (BDD, 1882) (h/d 2.8), *R. atropurpurea* (Locard & Caziot, 1899) (h/d 2.8), *R. densa* (Monterosato, 1884) (h/d 2.8), *R. oblonga* (Jeffreys, 1867) (h/d 2.5).

Raphitoma lineolata (Fig. 4) is very similar in general aspect, but differs in having a less robust shell and a narrower aperture, lacking the narrow subsutural ramp, and showing always few and scattered white tubercles on the last whorl as well as a subsutural white cord, both lacking in *spadiana*. *Raphitoma atropurpurea* has a different colour (dark brown-purplish vs. tawny). *Raphitoma densa* is more densely sculptured, and has a colour pattern of irregular ash-grey spots over a dark chestnut background. *Raphitoma oblonga* is exclusively Atlantic, and differs by its narrower aperture and the constant presence of a white spiral line as long as the space of four axial ribs, starting on the outer lip.

According to the admittedly limited material examined, *R. spadiana* seems to show some interpopulational variation, even over a short geographic scale (which would be congruent with a non-planktotrophic larval development), with at least one extreme case. A lot of 20 adult shells from Scilla (Calabria) range between 5.2-7.8 mm (mean 6.67) in height, and 2.5-3.9 mm (mean 3.16) in width, with h/d 2.11, and are darker that all other examined shells. Given the small number of shells available overall for comparison, we keep this lot within the putative range of *R. spadiana*.

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New species of neogastropods from the islands of the Gulf of Guinea, West Africa

Nuevas especies de neogasterópodos de las islas del golfo de Guinea, África occidental

Emilio ROLÁN* and Sandro GORI**

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ABSTRACT

Material collected from a recent expedition by the second author (SG) to Principe Island in the Guinean Gulf is studied. Material from nearby islands that was waiting for publication is also included. The new species proposed here belong to the genera *Anachis* (1 species) and *Mitrella* (1 species) in the family Columbellidae, and *Mitromorpha* (3 species) in the family Mitromorphidae, superfamily Conoidea.

RESUMEN

Se estudia el material recogido en una reciente expedición del segundo autor (SG) a la isla de Príncipe en el Golfo de Guinea. Al tiempo se incorpora material de otras islas próximas que estaba pendiente de publicación. Los géneros estudiados en los que se incluyen las nuevas especies encontradas han sido *Anachis* (una especie) y *Mitrella* (una especie) de la familia Columbellidae, y *Mitromorpha* (tres especies) de la familia Mitromorphidae, superfamilia Conoidea.

INTRODUCTION

In recent years the second author (SG) made several trips to the islands of the Guinean Gulf, during which a number of samples were collected. When these were examined, a few new species were found. In the present paper we describe the ones belonging to the families Columbellidae Swainson, 1840 (genera *Anachis* and *Mitrella*) and Mitromorphidae Casey, 1904 (genus *Mitromorpha*) after the recent systematic changes in Bouchet, Kantor, Sysoev & Puillandre (2011). On the other hand, material collected on a previous trip by the first author (ER), was mentioned in a previous paper (Rolán & Boyer, 2001), but has now been examined again and compared with the new material collected, enabling us to reach new conclusions regarding its status, which leads us to describe here a further two new species.

Abbreviations used:

MHNS Museo de Historia Natural de la Universidad, Santiago de Compostela
MNCN Museo Nacional de Ciencias Naturales, Madrid, Spain
MNHN Muséum National d'Histoire Naturelle, Paris, France

* Museo de Historia Natural, Universidad de Santiago, Campus Universitario Sur, 15782 Santiago de Compostela, Spain
** Via Sernesi, 7, 57123 Livorno, Italia

MCZ Museum of Comparative Zoology, Cambridge, USA
NHMUK Natural History Museum, London, England
CFS collection of Francisco Sicilia Guillén, Arrecife, Spain
CMS collection of Manuel Suárez, Ferrol, Spain
CPR collection of Peter Ryall, Maria Rain, Austria
CSG collection of Sandro Gori, Livorno, Italia

SYSTEMATIC PART

Family Columbellidae Swaison, 1840

Genus *Anachis* H. & A. Adams, 1853

H. & A. Adams (1858) defined the genus *Anachis* in the following terms: "Shell ovately-fusiform; spire elevate, whorls longitudinally ribbed; aperture narrow; columella straight; outer lip somewhat rectilinear, crenate internally". Thirteen species are known in the Eastern Atlantic region (including the Macaronesian Archipelagos, the Mediterranean and the West African coast).

Some species of this genus in West Africa were described long ago, the first being *Anachis cuspidata* Marrat, 1877. Not many more species were found over the years and by the end of the XXth century, only five more had been described, the latest being *Anachis avaroides* Nordsieck, 1975. All of these species were described singly and they have mostly a limited geographical range. As the result of the frequent collecting trips made by many malacologists to several countries in the area, it is curious to point out that in the revisions and other papers published over the last 10 years (Rolán & Luque, 2002; Hernández & Boyer, 2005; Pelorce & Boyer, 2005; Rolán, 2005; Rolán & Boyer, 2006; Pelorce & Rolán, 2007; Rolán & de Oliveira, 2008; Horro & Rolán, 2010; Segers, Swinnen & de Prins, 2009), seven new species were described or studied: Only in one case (Pelorce & Boyer, 2005), however, are we to find two species together in this genus, the others having been described always individually.

Since most species have a paucispiral protoconch, presumably their geographical range is small. Only *Anachis avaroides* seems to have a larger distribution area in the Macaronesian archipelagos.

Anachis xani spec. nov. (Figs. 1-6)

Type material: Holotype (Figs. 1-3) in MNHN (24819); Paratypes in the following collections: MNCN (15.05/60002, 1 s, Fig. 4); MHNS (100561, 2 s); NHMUK (1); CPR (1); CSG (9).
Other material examined: 10 shells eroded or without protoconch, and 17 fragments from the type locality.
Type locality: Tinhosa Pequena, 01°22.52'N, 07°16.53'E, under rocks, 25 m, Principe Island.
Etymology: The species is named after Juan Manuel "Xan" Guerra, who is in charge of the shell collections of the Museo de Historia Natural "Luis Iglesias", University of Santiago de Compostela.

Description: Shell (Figs. 1-4) solid, broadly fusiform with a moderate high spire. Protoconch (Fig. 5) with 1 ½ whorls, sharply pointed and about 0.5 mm in maximum diameter, apparently smooth but with spiral micro striae (Fig. 6) and usually coloured with brown and whitish bands. Teleoconch of 4 ½ slightly convex whorls, with a distinct suture and a very small subsutural

Figures 1-5. *Anachis xani* spec. nov. 1-3: holotype, 5.0 mm (MNHN); 4: paratype, 5.5 mm (MNCN); 5: apex and protoconch of the holotype; 6: detail of the micro sculpture.
Figuras 1-5. Anachis xani *spec. nov. 1-3: holotipo, 5,0 mm (MNHN); 4: paratipo, 5,5 mm (MNCN); 5: ápice y protoconcha del holotipo; 6: detalle de la microescultura.*

shelf. Sculpture formed by axial ribs, badly defined subsuturally, a little irregular, with variable interspaces, about 20 in the two first whorls; in the last whorl, about 15-19 can be observed, but on the last quarter of the whorls, they are almost entirely faded. There are no clear spiral threads, but under high magnification numerous micro striae can be seen: about 10 on first whorl, 13-15 on the second and about 24-28 on the third. Towards the base about 12-13 well marked striae form evident cords. Aperture narrow and axially elongate, usually with 6 teeth on the inner part of the external lip, the upper ones being larger. Columella curved, S-shaped, with 2 denticles usually almost unnoticeable. Shell colour brownish with a pattern of numerous ocellae which are a little larger below the suture, mainly on the last quarter of the shell.

Soft parts, operculum and radula unknown.

Dimensions: The holotype is 5.0 mm; the largest paratype reaches 6.0 mm.

Distribution: Only known from Principe Island.

Remarks: The differences with previously known species are as follows:

Anachis cuspidata (Marrat, 1877) has a larger (about 7-8 mm) shell, the colouration is very variable, the ocellated pattern very uncommon. Known from Senegal.

Anachis avaroides Nordsieck, 1975 has a larger and wider shell, variable in colouration but usually lacking an ocellated pattern; the axial ribs are not numerous, and it lacks spiral sculpture. It is known from the Azores, Madeira, Selvagem Islands and Canaries.

Anachis valledori Rolán & Luque, 2002 has a smaller and narrower shell, narrow and elongate axial ribs, variable but not ocellated colouration. Endemic to Cape Verde Islands.

Anachis ryalli Rolán, 2005 has a larger and narrower shell, of uniform tan color, the protoconch is more elevated, spiral threads only noticeable in the intervals. Collected in Ghana.

Anachis delamarrei Rolán & Boyer, 2006 has a smaller shell, protoconch with more whorls, fewer axial ribs and it lacks spiral sculpture. Colour uniformly dark brown. Known from Gabon.

Anachis delineata Rolán & de Oliveira, 2008 has a larger shell, with few axial ribs; the colouration comprises bands with an ocellated pattern alternating with others with white blotches. Known from the Cape Verde Islands.

Anachis juani Horro & Rolán, 2010 has a shell with strong axial sculpture but fewer ribs; the spiral cords are strong, about 20 on the last whorl; it lacks an ocellated pattern and has a light band on the last whorl. It is from Angola.

Mitrella annobonensis Rolán, 2005 is rather similar, having less axial sculpture, less white spots, ¼ shorter protoconch with different microsculpture (see Rolán, 2005: fig. 138-139). Perhaps this species, due to its axial ribs, could be placed in *Anachis* better than in *Mitrella*.

Genus *Mitrella* Risso, 1826

Remarks: In the same previously mentioned works in which *Anachis* species were described, species of the genus *Mitrella* also appeared. This genus includes a larger number of species, and about 30 are presently known for the area that includes Mediterranean, Macaronesian and West African shores. In this genus, there are species with large distribution ranges, such as *Mitrella ocellata* (Gmelin, 1791) which reaches the West Atlantic coast, or *Mitrella melvilli* Kudsen, 1956 from the West African coast, which have a multispiral protoconch. Most of the species, however, like *Mitrella broderipi* (Sowerby, 1844) from the Mediterranean and the Macaronesian archipelagos, have a short paucispiral protoconch and several of these are endemic to small areas.

Mitrella siciliai spec. nov. (Figs. 7-9)

Type material: Holotype (Fig. 7) in MNHN (24820). Paratypes in the following collections: MNCN (15.05/60003, 1 s, Fig. 8), MHNS (100562 , 1 s), NHMUK (1 s), CFS (1); CPR (1); CSG (3 s, Fig. 9).
Type locality: Tinhosa Pequena, 01° 20.33′ N, 07° 17.35′ E, under rocks, 25 m, Principe Island.
Etymology: Named after Francisco Sicilia Guillén, from Arrecife, Lanzarote, mollusc expert, friend and companion of many diving trips.

Description: Shell (Figs. 7-9) solid, broadly fusiform with a moderately high spire. Protoconch with about 1 1/2 whorls, sharply pointed and about 0.65 mm in maximum diameter, apparently smooth, usually coloured with cream and a brown line within. Teleoconch of between 5 - 5 1/2 slightly convex whorls, with distinct suture and a very small subsutural shelf. There is no any axial or spiral sculpture, only growth lines. Towards the base about 10 well marked striae form evident cords, the upper ones being wider. Aperture narrow and axially elongate, usually 6 teeth on the inner part of external lip, the upper one being larger, with a larger space before the following two, which are closed. Columella curved, S-shaped, with about 3 very small denticles, usually almost unnoticeable. Shell colour brownish with a pattern of numerous white ocellae, very variable and more or less apparent from one shell to another, and smaller white blotches which are a little larger below the suture. In the middle of the last whorl there is a dark irregular band interrupted by white circles and below it, these circles are smaller and more numerous.

Dimensions: Holotype is 8.3 mm. The paratypes are similar in size.

Distribution: Only known from Principe Island

Remarks: This species is slightly similar to the following:

Mitrella psilla (Duclos, 1846) is a smaller species present on the continental coast of West Africa, the teleoconch has one whorl less, the colour is lighter and more uniform, and the aperture has 4-5 denticles on the inner part of the external lip.

Besides other morphological differences, *Mitrella melvilli* Knudsen, 1956 and *M. africana* Rolán, 2005, both have a planktotrophic multispiral protoconch.

Mitrella inesitae Rolán, 2005 is larger, more elongate, the second tooth on the inner part of the external lip is larger, the base is not concave, the colour is lighter and the pattern different with a light band in the middle of the last whorl and brown blotches on the suture.

Mitrella aemulata Rolán, 2005 and *M. saotomensis* Rolán, 2005 have smaller and more fragile shells, lighter in colour, wider protoconch, and the small tubercles on the columella more evident.

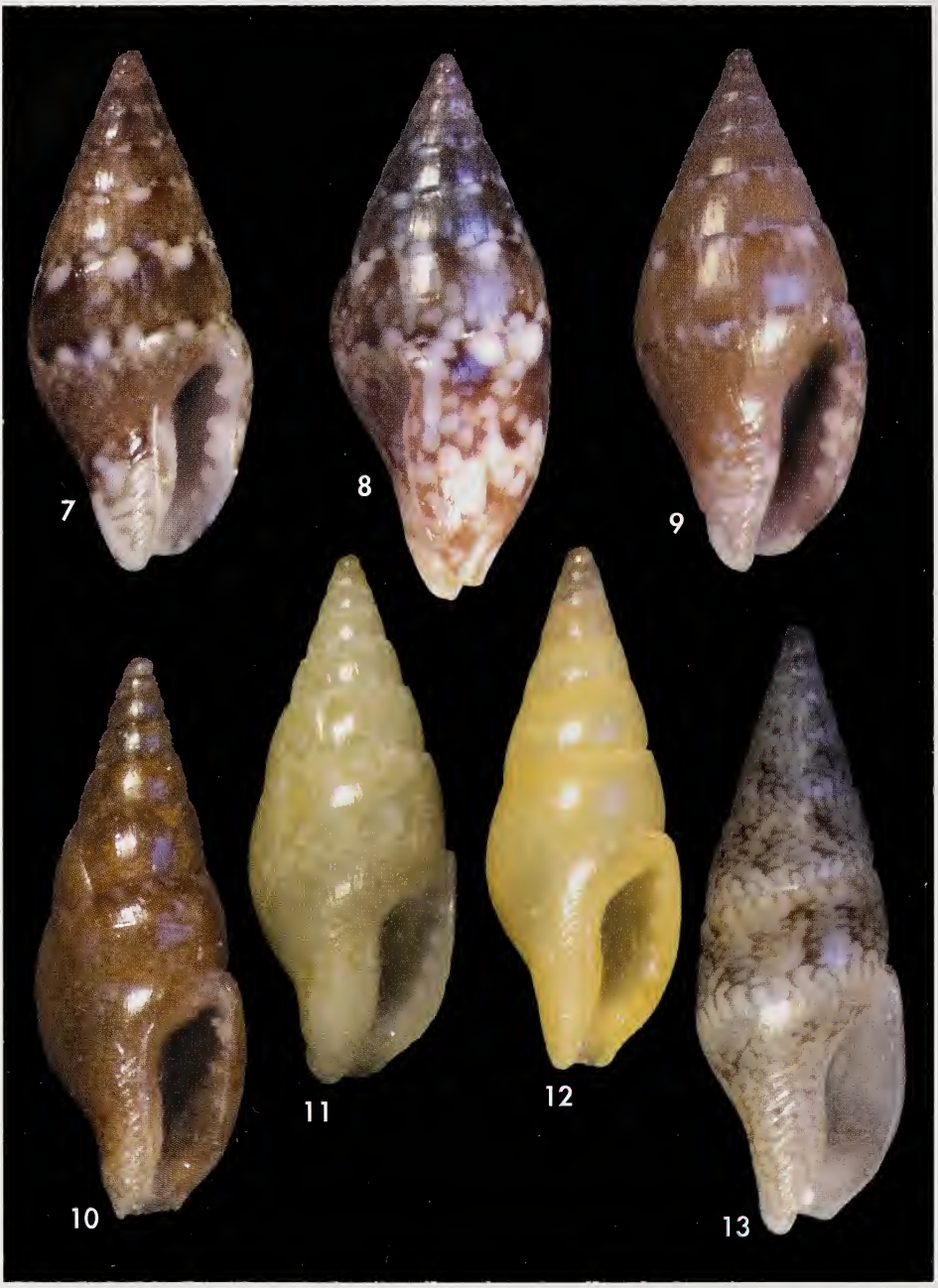
Mitrella annobonensis Rolán, 2005 is smaller in size with a lighter colour, relatively wider shell, with spiral striae and 5 teeth on the inner part of the external lip.

Mitrella noel Rolán & Gori, 2009 has larger shells (up to 9 mm) being also slender, more evident small tubercles on the columella, protoconch lighter, colour of the shell lighter presenting a different pattern with a brown irregular area on the upper part of the whorls.

Other *Mitrella* shells (Figs. 10-13)

In the material collected some other shells with different patterns appeared. The shells of the species of this genus are sometimes very similar at specific level, with an analogous colour and pattern. Others however may have a different pattern and variable colour. For this reason, when the collected sample consists of just a few specimens, only very clear differences can assure us that they are different, whereas small differences may only hint at specific separation, without allowing us to decide whether we are dealing with one or two separate species.

Mitrella cf. *tenebrosa* Rolán, 2005 (Fig. 10); collected in Minerio, in tangle nets,



Figures 7-9. *Mitrella siciliai* spec. nov. 7: holotype, 8.3 mm (MNHN); 8: paratype, 8.8 mm (MNCN); 9: paratype, 8.3 mm (CSG). Figures 10-13. Other *Mitrella*. 10: *Mitrella* cf. *tenebrosa* Rolán, 2005, 8.9 mm (CSG); 11, 12: *Mitrella* sp., 8.3, 8.2 mm (CSG); 13: *Mitrella* cf. *noel* Rolán & Gori, 2009, 9.4 mm (CSG).

Figuras 7-9. Mitrella siciliai *spec. nov. 7: holotipo, 8,3 mm (MNHN); 8: paratipo, 8,8 mm (MNCN); 9: paratipo, 8,3 mm (CSG). Figuras 10-13. Otras* Mitrella.*10:* Mitrella *cf.* tenebrosa *Rolán, 2005, 8,9 mm (CSG); 11, 12:* Mitrella *sp., 8,3, 8,2 mm (CSG); 13:* Mitrella *cf.* noel *Rolán & Gori, 2009, 9,4 mm (CSG).*

Figures 14-17. *Mitromorpha hernandezi* spec. nov. A: 14, 15: holotype, 4.5 mm (MNCN); 16: paratype, 4.4 mm (MNHN); 17: protoconch.
Figuras 14-17. Mitromorpha hernandezi *spec. nov. A: 14, 15: holotipo, 4,5 mm (MNCN); 16: paratipo, 4,4 mm (MNHN); 17: protoconcha.*

48 m, São Tome, which is very similar to the holotype.

Mitrella sp. (Figs. 11, 12). Two light coloured shells, one of them with some ocellae similar to the previous shell. They were collected in Lagoa Azul, 00° 24′ 49″ N, 06° 36′ 43″ E, at 24 m, São Tomé. They could be the same species as the latter, but we do not really know the full variability of this species.

Mitrella cf. *noel* Rolán & Gori, 2009. These shells (Fig. 13), from Lagoa Azul, 00° 24′ 49″ N, 06° 36′ 43″ E, at 24 m, São Tome, have a certain similarity to *M. noel*, with a more minute pattern, but the variability of this species is not well known.

Family Mitromorphidae Casey, 1904

Genus *Mitromorpha* Carpenter, 1865

The species placed in this genus were previously included in *Mitrolumna* Bucquoy, Dautzenberg & Dollfus, 1883. More recently, Mifsud (2001) made a revision of the species of the Mediterranean and the Macaronesian archipelagos, employing for them the genus *Mitromorpha*. CLEMAM also keeps this genus as valid for these species.

West African species had been mentioned in the literature in scarce numbers. Only four species were known in the last century: *M. monodi* (Knudsen, 1956) from Senegal and *M. crenipicta* (Dautzenberg, 1889), *M. smithi* Dautzenberg & Fischer, 1896 from Azores. More recently, a fourth species from deep water was described by Bouchet & Warén (1980). In the last ten years Mifsud (2001) described several species from the Mediterranean and the Macaronesian archipelagos. Rolán & Boyer (2001) described two new species, one from Senegal and another from São Tome and presented also some morphs considered as variations.

Mitromorpha hernandezi spec. nov. (Figs. 14-17)

Type material: Holotype (Figs. 14-15) in MNCN (15.05/60004). Paratypes in the following collections: MNHN (24821, 1 s, Fig. 16); NHMUK (1 s); MHNS (100563, 7 s); MCZ (1 s), CPR (1 s); CSG (2 s).
Other material examined: 10 s (in bad condition), 1 j, 21 f (MHNS), from type locality; 7 s, and f, from San Antonio de Palé, 2-8 m.
Type locality: Isla Tortuga, Annobón Island, 12 m.
Etymology: The specific name is after José María Hernández, malacologist of Gran Canaria, recently passed away, a frequent companion of the authors on trips and dives.

Description: Shell (Figs. 14-16) small, solid, fusiform, almost biconical. Protoconch (Fig. 17) smooth and shiny, chestnut colored, with a nucleus of about 120 µm and a diameter of about 450 µm. Teleoconch usually with 4-4 $^1/_2$ whorls bearing a coarse sculpture of axial ribs, numbering 12-15 on the first whorl, 18-22 on the second and about 28 – 35 on the last one. These ribs are crossed by three spiral cords on the first whorls and 18-20 on the last. The crossing of ribs and cords gives the shell a reticulated aspect. Aperture elongate axially, columella opisthocline, with 2-3 small denticles; on the inner part of the external lip, there are about 10-12 small teeth, some of them more prominent. Colour brown and white: brown on the subsutural area and in the lower part of the last whorl below the periphery. A band just on the separation of these two parts is formed by blotches of brown and white. Towards the base, the brown colour is reduced to small rectangles on the spiral cords. In some shells a similar line can also be seen on the upper part of the shell.

Dimensions: Holotype is 4.5 mm; specimens may perhaps grow to be a little larger, but most of them are smaller, even between 3.3-4.0 mm

Distribution: Only known from Annobón, from where it is supposed to be endemic.

Remarks: In Rolán & Boyer (2001: figs. 28-29, 42, 45) the present species was figured as a morph of *M. saotomensis*. At the time, not enough material had been examined. Today, after having the opportunity to study more shells, we can point out the constancy of morphological differences with *M. saotomensis*. This and the isolation of both populations on two islands many kilometers apart, convinced us that *M. hernandezi* is a valid different species.

Mitromorpha saotomensis has a shell which is larger in size, darker, almost

black, very dense sculpture of axial ribs and spiral cords.

Mitromorpha monodi (Knudsen, 1956) is larger, whitish on the upper part, the protoconch is white, and it is endemic to Senegal.

Mitromorpha wilheminae Aartsen, Menkhorst and Gittenberger, 1984 is larger and wider, with a similar colour, but the axial sculpture is faded; moreover, it is endemic to the Mediterranean.

Mitromorpha annobonensis spec. nov. (Figs. 18-23)

Type material: Holotype (Figs. 18-19) in MNCN (15.05/60005). Paratypes in the following collections: MNHN (24822, 1 s, Fig. 20); NHMUK (1 s); MHNS (100564, 7 s, Fig. 21); CPR (1 s); CSG (1 s).
Other material examined: 10 s (in eroded conditions) and 5 f, from the type locality.
Type locality: San Antonio de Palé, Annobon Island, 5-8 m.
Etymology: The specific name refers to the island where it was collected.

Description: Shell (Figs. 18-21) small, solid, fusiform, almost biconical. Protoconch (Figs. 22-23) smooth and shiny, pink coloured, with a nucleus of about 150 µm and a diameter of about 410 µm. There is a kind of blunt angle on the subsutural part. Teleoconch usually with prominent nodulous spiral cords crossed by axial ribs forming nodules at the intersection points. There are three of these spiral cords on the first whorls and on the last whorl, below the end of the spire, there are 9-13 additional cords, with slightly smaller nodules. There are 13-16 axial ribs on the first whorl, and 14-20 on the subsequent ones. Aperture narrow and elongate, columella opisthocline, almost straight and with very small teeth in the middle. On the inner part of the external lip there are 7-9 small teeth, of which the second on the upper part is larger and more prominent. Colour pink with lighter nodules on the upper part of the last whorl and darker on band which continues the suture, and in some points more. Towards the base, the colour is lighter.

Dimensions: Holotype is 4.3 mm, like most of the paratypes.

Distribution: Only known from Annobón, from where it is supposed to be endemic.

Remarks: *Mitromorpha annobonensis* spec. nov. was figured in ROLÁN & BOYER (2001: figs. 26-27, 41 and 43) as a form of *M. saotomensis* Rolán & Boyer, 2001. At present, after a careful comparison, we can state that they are different species. It must be distinguished from the closest species by the spiral angle of the protoconch which was not found in any other species. Other morphological differences are:

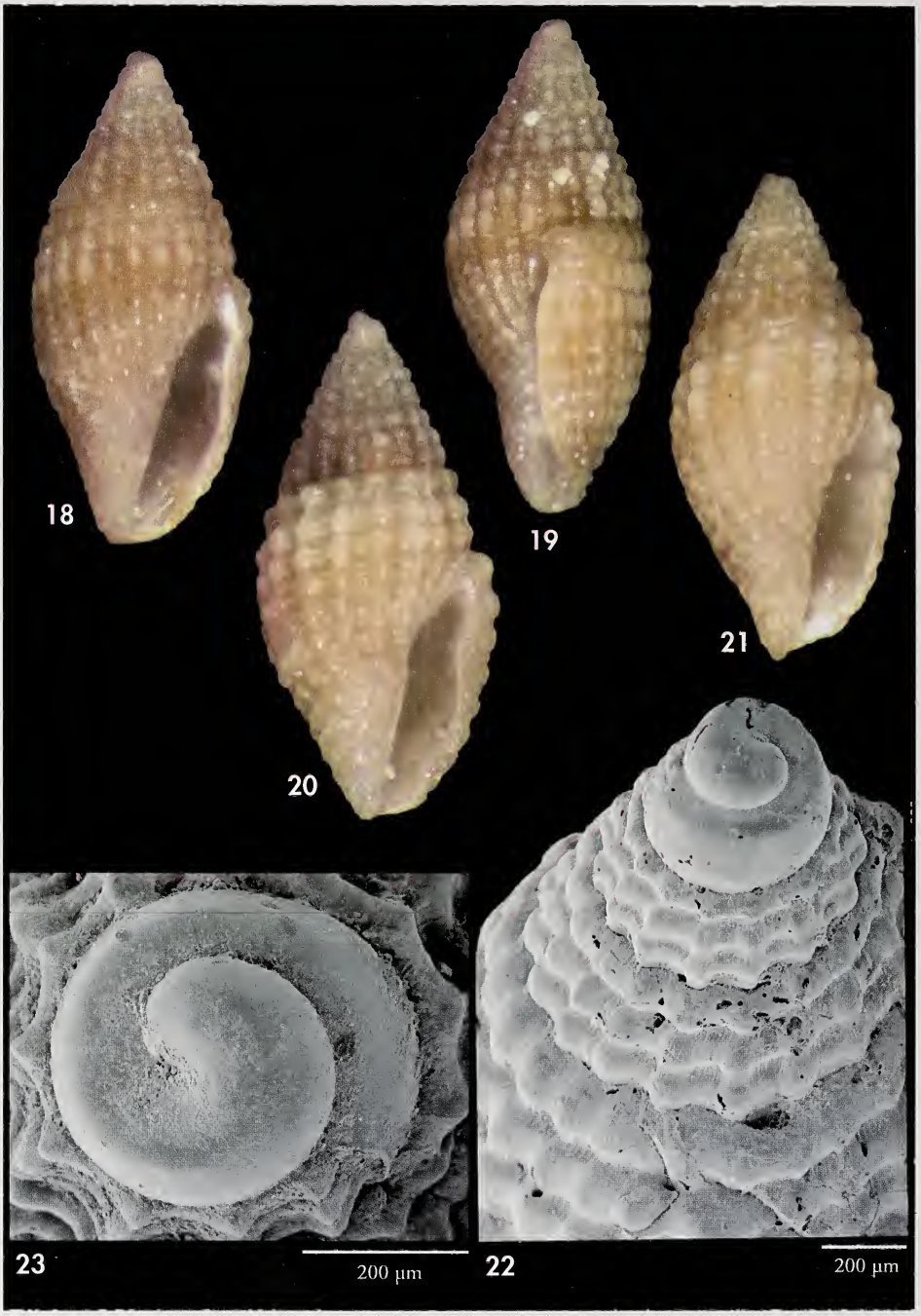
M. saotomensis is darker, almost black; the number of spiral cords on the whorls is higher (21 to 30 on the last one). Also the axial ribs are denser; the protoconch is rounded, lacking any angle and presenting micro tubercles.

M. monodi (Knudsen, 1956) is larger and the upper middle part of the shell and the protoconch are whitish.

M. hernandezi spec. nov. lives in sympatry and is smaller, more densely sculptured in axial ribs and spiral cords, the upper part of the last whorls is lighter with separation from the lowest dark one.

Mitromorpha suarezi spec. nov. (Figs. 24-25)

Type material: Holotype (Figs. 24) in MNHN (24823). Paratypes in the following collections: MNCN (15.05/60006, 1 s, Fig. 24); NHMUK (1 s); MHNS (100565, 1 s); CMS (1 s), CPR (1 s), CSG (4 s),
Other material examined: 24 s eroded and f, from the type locality.
Type locality: Tinhosa Pequena, 01° 20.33′ N, 07° 17.35′ E, under rocks, 25 m, Principe Island.
Etymology: The specific name is after Manuel Suarez Bustabad, enthusiastic malacologist from Ferrol (A Coruña), Spain.

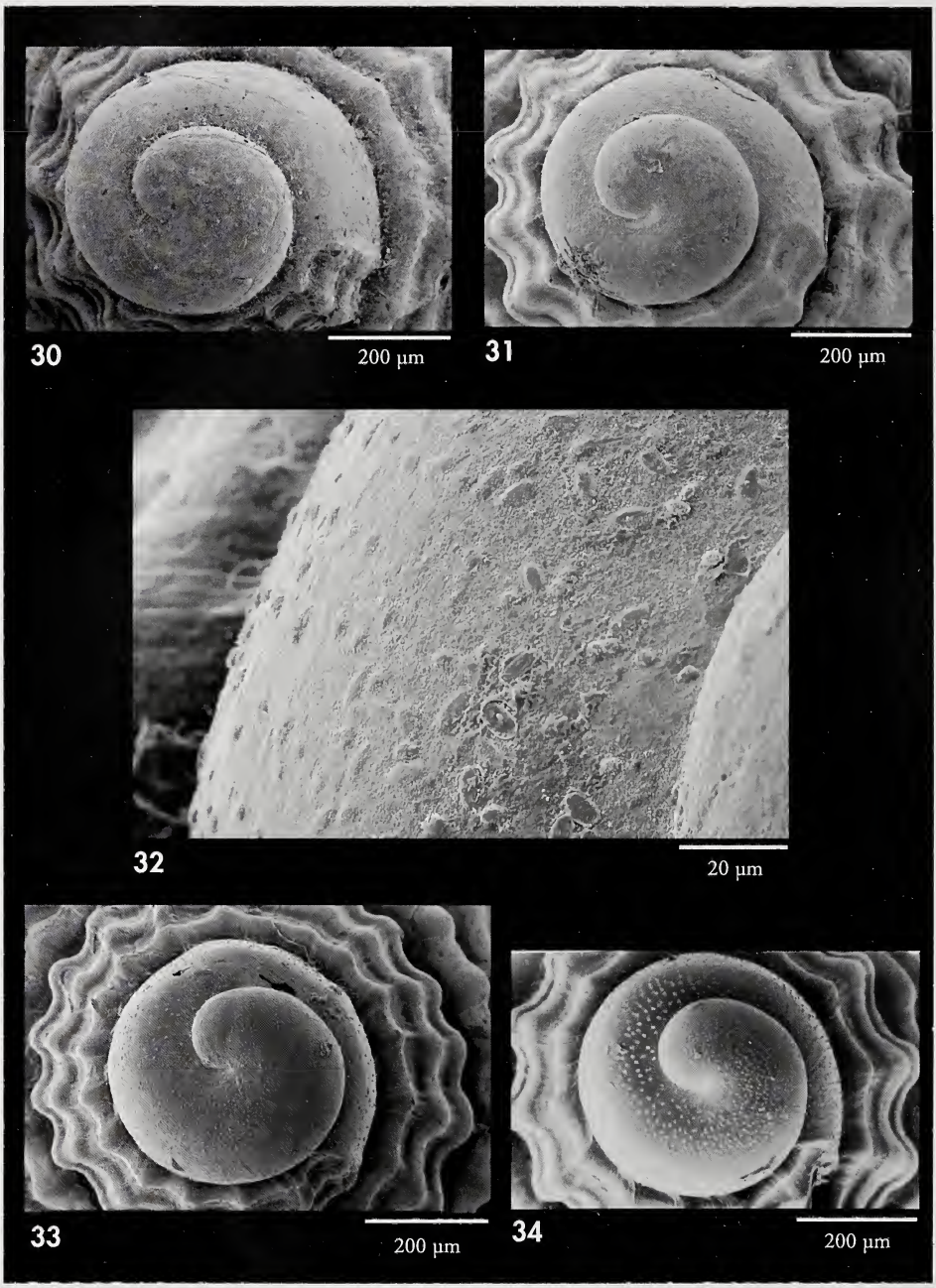


Figures 18-22. *Mitromorpha annobonensis* spec. nov. 18, 19: holotype, 4.3 mm (MNCN); 20: paratype, 4.3 mm (MNHN); 21: paratype, 4.0 mm (MNHN); 22: apex with protoconch; 23: detail of the protoconch.

Figuras 18-22. Mitromorpha annobonensis *spec. nov. 18, 19: holotipo, 4,3 mm (MNCN); 20: paratipo, 4,3 mm (MNHN); 21: paratipo, 4,0 mm (MNHN); 22: ápice con protoconcha; 23: detalle de la protoconcha.*

Figures 24, 25. *Mitromorpha suarezi* spec. nov. 24: holotype, 4.7 mm (MNHN); 25: paratype, 4.6 mm (MNCN). Figures 26-29. *Mitromorpha saotomensis* (Rolán & Boyer, 2001); 26: holotype, 5 mm (MNCN); 27: paratype, 5.3 mm (MNHN). Both from Esprainha, São Tomé; 28, 29: shells, 4.3 and 4.9 mm, Sete Brazas, Principe Island, 01° 39.13' N, 07° 28.13' E, 20 m.

Figuras 24, 25. Mitromorpha suarezi *spec. nov. 24: holotipo, 4,7 mm (MNHN); 25: paratipo, 4,6 mm (MNCN). Figuras 26-29.* Mitromorpha saotomensis *(Rolán & Boyer, 2001); 26: holotipo, 5 mm (MNCN); 27: paratipo, 5,3 mm (MNHN). Ambas de Esprainha, São Tomé; 28, 29: conchas, 4,3 y 4,9 mm, Sete Brazas, Isla de Príncipe, 01° 39.13' N, 07° 28.13' E, 20 m.*



Figures 30-34. Protoconchs of *Mitromorpha*. 30: *Mitromorpha suarezi* spec. nov. 31-34: *Mitromorpha saotomensis* (Rolán & Boyer, 2001). 31: shell from Sete Brazas, Principe Is. (CSG); 32: detail of the microsculpture; 33: shell from Principe, Tinhosa Pequena; 34: shell from São Tomé, Baía das Agulhas (from ROLÁN & BOYER, 2001).

Figuras 30-34. Protoconchas de Mitromorpha. *30:* Mitromorpha suarezi *spec. nov. 31-34:* Mitromorpha saotomensis *(Rolán & Boyer, 2001). 31: concha de Sete Brazas, Isla de Príncipe (CSG); 32: detalle de la microescultura; 33: concha de Príncipe, Tinhosa Pequena; 34: concha de São Tomé, Baía das Agulhas (de ROLÁN & BOYER, 2001).*

Description: Shell (Figs. 24-25) small, solid, fusiform, almost biconical. Protoconch (Fig. 30) smooth and shiny, coloured from pink to brown, with a nucleus of about 110 µm and a diameter of about 480 µm. Teleoconch usually with 4-4 $^1/_2$ whorls bearing a coarse sculpture of axial ribs and spiral cords. There are about 12 ribs on the first whorl, 14-17 on the second and 20-28 on the last one. There are three ribs on the first whorls and on the last, about 14-16 more from the end of the spire. Aperture narrow and elongate axially, columella a little undulating with two small teeth; on the inner part of the external lip, there are about 10 teeth, the second one larger and prominent. The colour is cream on the upper part of the shell, with an isolated brown rectangle on the suture and darker below; towards the base it is light again with small brown rectangles on the spiral cords.

Dimensions: Holotype is 4.7 mm.

Distribution: Only known from the type locality.

Remarks: *Mitromorpha suarezi* spec. nov. has some similarity to *M. hernandezi* spec. nov., in the pattern and colouration but they can obviously be distinguished: *M. hernandezi* has a slightly smaller shell, its colour is lighter with yellowish on the upper part of the whorls; the protoconch is a little narrower.

Mitromorpha saotomensis (Rolán & Boyer, 2001) has a similar shape, a darker shell, being more densely sculptured. It could be considered a variation, but in the same place where *M. suarezi* was collected, there is also a population of the typical *M. saotomensis* (Figs. 28-29) living sympatrically without intergradations. This population is more similar to that of São Tome only being a little smaller. In ROLÁN & BOYER (2001: figs. 33-34) also were represented shells from Principe I. (Baía das Agulhas). In this last species the presence of tubercles on the protoconch was noticed several times (Figs. 31-34). This could not be shown in *M. suarezi* but perhaps the protoconchs studied were a little eroded.

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The genus *Gibberula* (Gastropoda, Cystiscidae) in the Cape Verde Islands with the description of a new species

El género *Gibberula* (Gastropoda, Cystiscidae) en el archipiélago de Cabo Verde con la descripción de una nueva especie

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ABSTRACT

The species of the genus *Gibberula* from the Cape Verde islands are reviewed. There are at least four species, three previously described: *Gibberula lucia* Jousseaume, 1877, *G. rauli* Fernandes, 1987 and *G. rolani* Cossignani and Cecalupo, 2005, and one new species, *G. elvirae* n. sp. is here described. *Gibberula rachmaninovi* Kellner, 2003, is considered here as a synonym of *Volvarina sauliae* (Sowerby, 1846).

RESUMEN

Se revisan las especies del género *Gibberula* del archipiélago de Cabo Verde. Existen, al menos, cuatro especies, tres descritas previamente: *Gibberula lucia* Jousseaume, 1877, *G. rauli* Fernandes, 1987 y *G. rolani* Cossignani y Cecalupo, 2005, y una especie nueva que se describe en este trabajo: *G. elvirae* n. sp. Por último, *Gibberula rachmaninovi* Kellner, 2003, es considerado un sinónimo de *Volvarina sauliae* (Sowerby, 1846).

INTRODUCTION

The genus *Gibberula* belongs to the family Cystiscidae which, together with the closely related family Marginellidae, are known as "Marginelliform" gastropods, and are one of the most conspicuous elements of the West African malacofauna.

The molluscan fauna of the Cape Verde Islands has been studied by many authors: Jousseaume (1877), Rochebrune (1881a, b), Dautzenberg (1910), Melvill and Standen (1913), Burnay and Monteiro (1977), Saunders (1977), García-Talavera and Bacallado (1979), Cosel (1982a, b, c), Fernandes (1987), Moreno and Burnay (1999), Guerreiro and Reiner (2000), Kellner (2003), Rolán (2005) and Cossignani and Cecalupo (2005).

There are six species names for *Gibberula* listed in the literature, either described with a type locality in the Cape Verde Islands or cited for the Archipelago. The Mediterranean species *Gibberula miliaria* (Linnaeus, 1758) and *G. philippii* (Monterosato, 1878) were erroneously cited in the Cape Verde Islands and are not present in the archipelago. Another species, *Gibberula rachmaninovi* Kellner, 2003, described from the Cape Verde islands as a *Gibberula* will here be shown to belong to a different genus, *Volvarina*. The genus *Gibberula* is represented in the Cape Verde Archipelago by four species, either endemic, as *G. rauli* Fernandes, 1987, *G. rolani* Cossignani and Cecalupo, 2005,

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Table I. Localities studied in the Cape Verde Archipelago with species of the genus *Gibberula*, showing the coordinates and the origin of the samples (see abbreviations used).
Tabla I. Localidades de estudio en el archipiélago de Cabo Verde con especies del género Gibberula, *mostrando las coordenadas y origen de las muestras (ver abreviaturas utililizadas).*

Nº	Island	Locality	Coordinates (Datum WGS84)	Origin of the samples
1	Sal	Ponta Preta	16º48'N; 22º59'W	ER
2	Sal	Rigona	16º47'N; 22º59'W	PEICV and ER
3	Sal	Baia Palmeira	16º45'N; 22º58'W	PEICV
4	Sal	Rabo de Junco	16º41'N; 22º57'W	ER
5	Sal	Baia Mordeira	16º40'N; 22º56'W	ER
6	Sal	Baia Algodoeiro	16º37'N; 22º55'W	ER
7	Sal	Santa Maria	16º35'N; 22º54'W	PEICV
8	Sal	Fiura	16º50'N; 22º54'W	PEICV
9	Sal	Palhona	16º50'N; 22º57'W	ER
10	Sal	Monte Leste	16º49'N; 22º58'W	ER
11	São Vicente	Salamanza	16º54'N; 24º57'W	PEICV
12	São Vicente	Callhau	16º51'N; 24º52'W	RVC-MNHN
13	Boavista	Baia Sal Rei	16º10'N; 22º55'W	PEICV
14	Boavista	Derrubado	16º14'N; 22º46'W	ER
15	Santiago	Praia	14º54'N; 23º30'W	AO
16	Brava	Baia Pedrinha	14º54'N; 24º41'W	ER
17	Brava	Furna	14º53'N; 24º40'W	ER

and the new species described in the present paper, or with a very restricted distribution area, as *G. lucia* Jousseaume, 1877, cited also in Senegal (Knudsen, 1956; Pin and Boyer, 1995).

The pigmentation patterns of the head-foot and mantle in the living animals are usually bright and have been shown to be stable and extremely informative for the separation of closely related species (Fernandes, 1987; Gofas, 1989a, 1989b, 1990; Moreno and Burnay, 1999) and will be given particular attention in this paper. Also the radula features are important for separating species (Moreno and Burnay, 1999).

MATERIAL AND METHODS

Most of the material examined was collected during the "Primera Expedición Ibérica a Cabo Verde" (PEICV) excursion to the Cape Verde Islands, in which the author took part (August 1985). Specimens were hand-picked while scuba-diving or snorkeling between 0 and 5 m depth in the islands of Sal, Boavista and São Vicente. Most specimens were collected between -1 and -2 meters on rocky bottoms with coral slabs. Other islands were visited (Santa Luzia, São Nicolau and Santiago) but only a limited sampling effort could be carried out (snorkeling) and no specimens of this genus were obtained.

Other material studied was collected by L.P. Burnay in the years 1975-1976 (IIT), by R. von Cosel in 1978 (São Vicente Island, at MNHN), by E. Rolán in the years 1978, 1979, 1980, 1981, 1986, 1987, 1988 and 2001 (Sal, Boavista and Brava), and by A.D. De Oliveira in 2005 (Santiago). Specimens of *Gibberula oryza* (Lamarck, 1822), the type species of the genus, were studied and photographed alive at Punta Carnero, Cádiz, in the Strait of Gibraltar (1997). All localities studied are shown in Table I and in the map of Figure 1.

The clarification of the complex taxonomic problems in the genus is mainly based on the observation of pigmentation patterns, and therefore required collecting and sorting the animals alive. The

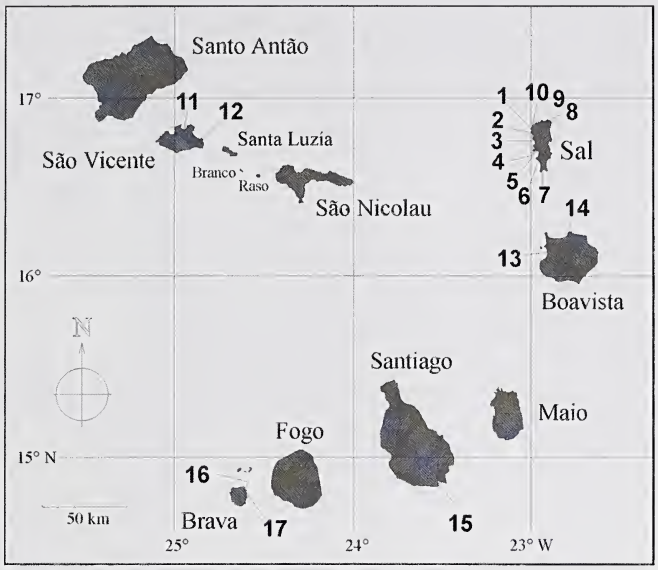


Figure 1. Map of Cape Verde Archipelago and localities where the studied material of the genus *Gibberula* was collected (origin of the samples in brackets). Coordinates in Table I. Sal Island, 1: Ponta Preta (ER); 2: Rigona (PEICV) and (ER); 3: Baia Palmeira (PEICV); 4: Rabo de Junco (ER); 5: Baia Mordeira (ER); 6: Baia Algodoeiro (ER); 7: Santa Maria (PEICV); 8: Fiura (PEICV); 9: Palhona (ER); 10: Monte Leste (ER). São Vicente Island, 11: Salamanza (PEICV); 12: Calhau (RVC-MNHN). Boavista Island, 13: Baia Sal Rei (PEICV); 14: Derrubado (ER). Santiago Island, 15: Praia (AO). Brava Island, 16: Baia Pedrinha (ER); 17: Furna (ER).

Figura 1. Mapa del archipiélago de Cabo Verde y localidades donde se recolectó el material estudiado del género Gibberula *(origen de las muestras entre paréntesis). Coordenadas en la Tabla I. Isla de Sal, 1: Ponta Preta (ER); 2: Rigona (PEICV) y (ER); 3: Baia Palmeira (PEICV); 4: Rabo de Junco (ER); 5: Baia Mordeira (ER); 6: Baia Algodoeiro (ER); 7: Santa Maria (PEICV); 8: Fiura (PEICV); 9: Palhona (ER); 10: Monte Leste (ER). Isla de São Vicente, 11: Salamanza (PEICV); 12: Calhau (RVC-MNHN). Isla de Boavista, 13: Baia Sal Rei (PEICV); 14: Derrubado (ER). Isla Santiago, 15: Praia (AO). Isla Brava, 16: Baia Pedrinha (ER); 17: Furna (ER).*

living animals were observed under a stereomicroscope, and coloured drawings prepared to take note of the patterns and tones of pigmentation. In some cases, colour slides were also taken.

The radulae were extracted from adult specimens using potassium hydroxyde on whole animals soaked in water. At least one radula of each species was observed through a scanning electron microscope (MNCN).

Abbreviations used

AO: Alvaro David De Oliveira Ramos and his private collection (Gulpilhares, Portugal)

ER: Emilio Rolán and his private collection (Vigo, Spain).

IIT: Instituto de Investigação Tropical (Centro de Zoologia), Lisboa, Portugal.

MNCN: Museo Nacional de Ciencias Naturales, Madrid.

MNHN: Muséum National d'Histoire Naturelle, Laboratoire de Malacologie, Paris, France.

PEICV: Primera Expedición Ibérica al Archipiélago de Cabo Verde (1985).

RVC: Rudo Von Cosel (MNHN, Paris, France).

UAM: Universidad Autónoma de Madrid, Spain (Departamento de Biología, Zoología).

SYSTEMATIC PART

Family Cystiscidae Stimpson, 1865
Genus *Gibberula* Swainson, 1840

Type species *Gibberula zonata* Swainson, 1840 by monotypy (= *Volvaria oryza* Lamarck, 1822), as stated Gofas (1990: 115) (Fig. 17).

The shell of the species of the genus *Gibberula* is ovate-cylindrical, sometimes somewhat pyriform with a very developed body whorl covering almost all of the earlier whorls. The shell is translucent in the smaller species, so that the inner mantle may be visible by transparency. The protoconch is paucispiral as in all marginelliform gastropods. The aperture is elongate and narrow and has anteriorly a rounded siphonal canal. The columella has plaits on its anterior half, decreasing in size towards the apical end. The outer lip, in adults, is always thickened, with usually numerous denticles on the inner margin. The shell surface is glossy, without colour, with spiral pigmented bands or more rarely with wavy axial flames.

The animal (type 4 following Coovert and Coovert, 1995) is active, fast-moving, and creeps on the foot which is truncated anteriorly and rounded posteriorly. The head is small, deeply cleft in two parts and provided with a pair of short tentacles. The eyes are small, without lateral bulges as in the Marginellidae. The siphon lies over the head and it is cleft on its lower side. The mantle does not cover the shell as other marginelliform gastropods. The pigmented areas are on the upper part of the foot, the head, the siphon and tentacles, and the mantle. The most common colours are black, orange and opaque white. The upper part of the foot, siphon and head are usually more brightly pigmented. When the animal is withdrawn, the pigmentation of the inner mantle may be seen through the shell.

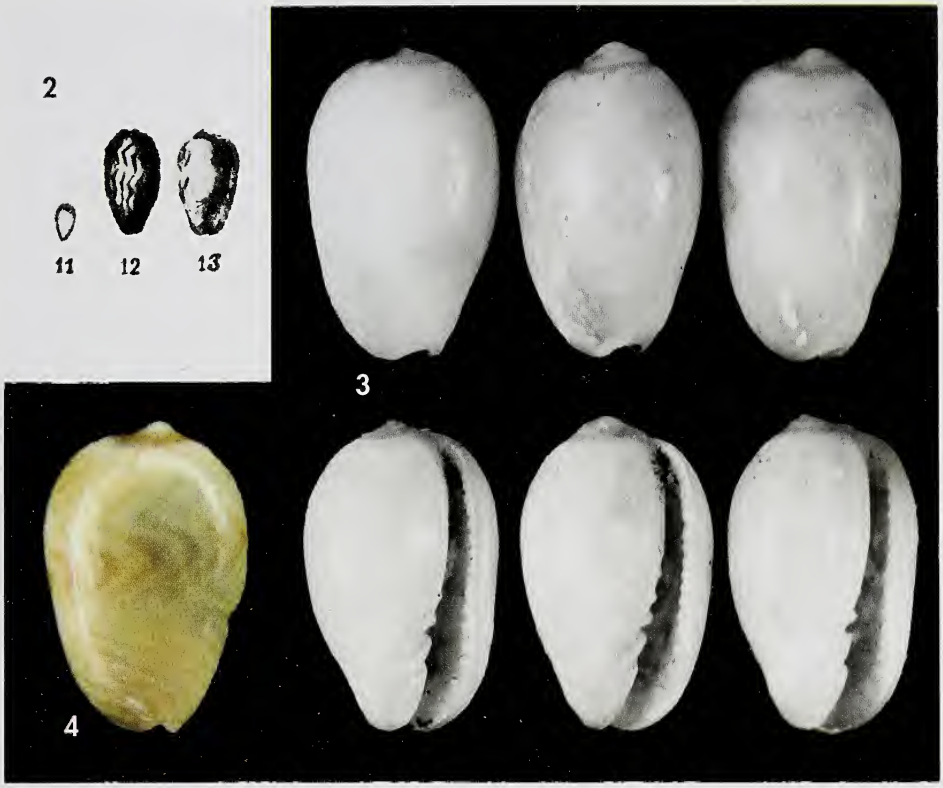
The radula (type 3 following Coovert and Coovert, 1995), is rachiglossan, reduced to a central rachidian tooth per line, which is V-shaped, between 0.008 and 0.042 mm wide, with several cusps (5-11). The ratio shell length/tooth width (L/Wr) in the genus is between 118 and 309 (Coovert and Coovert, 1995).

Gibberula lucia Jousseaume, 1877 (Figs. 2-4)

Gibberula lucia Jousseaume, 1877: 269-270, pl. V, figs. 11-13 (Santa Luzia Island, Cape Verde Archipelago).
Other references:
Marginella (Glabella) lucia (Jousseaume, 1876) [sic]: Tryon, 1883.
Gibberula lucia Jousseaume, 1877: Tomlin, 1917; p. 277.
Marginella lucia (Jousseaume, 1876) [sic]: Knudsen, 1956; p. 88, Pl. 1, Fig. 4 (Gorée, Senegal).
Marginella lucia (Jousseaume, 1876) [sic]: Wagner and Abbott, 1967; p. 156.
Gibberula lucia Jousseaume, 1876 [sic]: Pin and Boyer, 1995; p. 56, Figs. 7-9 (Dakar, Senegal).

Other references (doubtful):
?*Gibberula miliaria* (Linnaeus, 1758): Rochebrune, 1881b; p. 293 (Porto-Praya in Santiago Island, Cape Verde Archipelago).
?*Persicula miliaria* (Monterosato) [sic]: García-Talavera and Bacallado, 1979; p. 207 (Mindelo and Gatas in São Vicente Island and Praia in Santiago Island, Cape Verde Archipelago).

Type material: 3 syntypes (MNHN) all of 3.5 mm length (Fig. 3 in the present paper).
Other material studied: Santiago Island: Praia, 1 sp., broken (AO) (Fig. 4).



Figures 2-4. *Gibberula lucia*. 2: figures 11, 12 and 13 of the original description by Jousseaume (1877); 3: three syntipes of *G. lucia* from Santa Luzia Island (MNHN) (3.5 mm); 4: specimen from Praia, Santiago Island collected by A. Oliveira (23-VII-2005) (4.0 mm).
Figuras 2-4. Gibberula lucia. *2: figuras 11, 12 y 13 de la descripción original de Jousseaume (1877); 3: tres sintipos de* G. lucia *de la isla de Santa Luzia (MNHN) (3,5 mm); 4: ejemplar de Praia, isla de Santiago, recogido por A. Oliveira (23-VII-2005) (4,0 mm).*

Remarks: The shell descriptions of JOUSSEAUME (1877) and KNUDSEN (1956) are good. The figure of this species by JOUSSEAUME (1877), reproduced here in Fig. 2, is deficient, but that of KNUDSEN (1956) from Senegal is better. PIN AND BOYER (1995) also made a description of shells from Dakar (Senegal) showing photographs of several specimens. There are no data about the animal and its colour pattern or radula.

Distribution: With the scarce data available, the species lives in Santa Luzia Island (Cape Verde Archipelago), and in the area of Dakar (Senegal), including Gorée Island, where it seems to be more abundant. So, this is the sole species of the genus living in the Cape Verde Islands that is not considered endemic. It still has a very restricted area of distribution, because Dakar is the closest point of the African continent to the Cape Verde Islands.

Discussion: The species, described with material from the desertic island of Santa Luzia by JOUSSEAUME (1877), has a shell with a very distinct colour pattern of brown lines in four groups: two of them comma-shaped that converge in the central part of the body whorl, another group near the suture and the last one along the base of the shell. This colour pattern matches that of the specimens from Gorée, Dakar (Senegal)

studied by KNUDSEN (1956). There has been no more material of this species recorded from the Cape Verde Islands since the description by JOUSSEAUME (1877), in spite of the numerous malacological expeditions to this area made in the last decades of the XX Century. The species was not cited by several authors who studied the malacofauna of the Cape Verde Islands, including COSEL (1982b) in a work about the molluscan fauna of Santa Luzia, the type locality of this species. Nevertheless a single specimen (Fig. 5) collected by A. Oliveira at Praia (Santiago Island) (23-VII-2005), confirms the presence of the species in the Cape Verde Islands, and silences the possible doubts that could exist about the Jousseaume material.

ROLÁN (2005) reports the name *Gibberula lucia* Jousseaume, 1876 [sic] erroneously as a synonym of *Gibberula* sp. 2., but not as a valid species. The species cited as *Gibberula* sp. 2 by ROLÁN (2005) was described in the same year as *Gibberula rolani* by COSSIGNANI AND CECALUPO (2005), and it is hereafter treated as a valid species, different from *G. lucia*.

Gibberula rauli Fernandes, 1987 (Figs. 5, 6, 14)

Gibberula rauli Fernandes, 1987: 265, figs. 3 and c (Sal, Boavista, Maio, Santiago and São Vicente islands, all in the Cape Verde Archipelago).

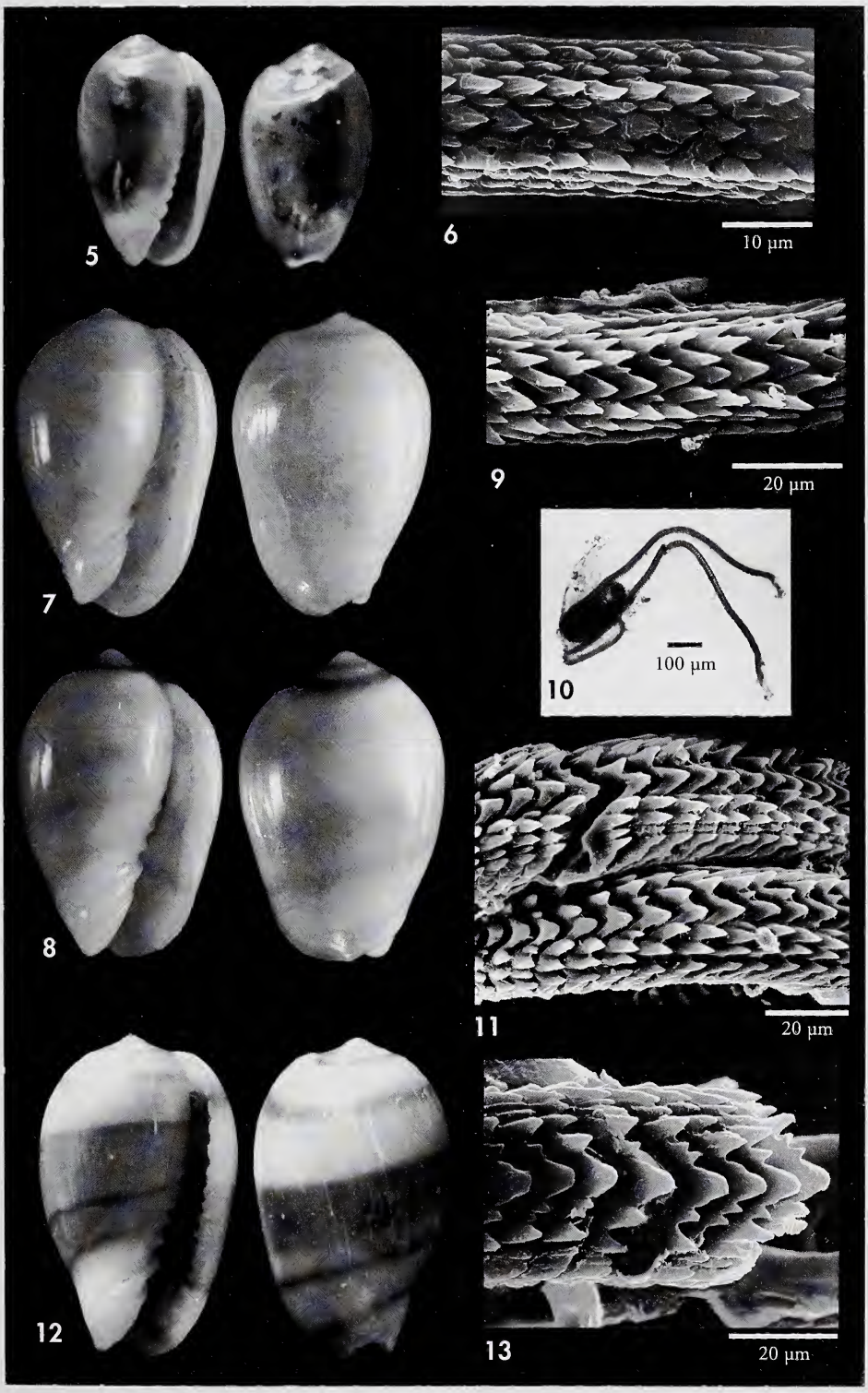
Gibberula philippii (Monterosato, 1878) [misidentification]: García-Talavera and Bacallado, 1979; p. 207 (Mindelo in São Vicente Island, Cape Verde Archipelago).

Gibberula rauli Fernandes, 1987: Rolán, 2005; p. 147, Figs. 642 and 778 (from throughout the Cape Verde Archipelago).

Material studied (all from the Cape Verde Islands): Boavista Island: Derrubado, 2 sp. (ER). Sal Island: Rabo de Junco, 2 sp. (ER). Rigona, 2 sp. (ER). Algodoeiro, 2 sp. (ER). São Vicente Island: Salamanza, 75 sp. + 10 sp. (PEICV). Brava Island: Baia Pedrinha, 137 sp. (ER). Furna, 5 sp. (ER).

Remarks: The shell description by FERNANDES (1987) is correct. This author included drawings of the shell and of the living animal. The shell, which is very transparent, is here shown photographed (Fig. 5). The animal is active and fast. The foot, rounded in its rear end, is longer than the shell when the animal is moving on the substratum. The head is small, divided into two parts, and the tentacles are very short. The pigmentation pattern (Fig. 14) on the foot and on the inner mantle observed by transparency, is white, with extensive black areas, very irregular in shape in the mantle. The siphon is white.

(Right page) Figures 5-13. Shells and radulae of species of *Gibberula* from Cape Verde Islands. 5, 6. *Gibberula rauli*, Salamanza, São Vicente (PEICV). 5: shells (2.2 and 2.1 mm); 6: radula. 7-11. *Gibberula rolani*. 7: shell from Sal Rei, Boavista (PEICV) (5.1 mm); 8: shell from Rigona, Sal (PEICV) (5.0 mm); 9: radula from Sal Rei, Boavista (PEICV); 10, 11: teratological double radula from Sal Rei, Boavista (PEICV); 10: double radula showing the odontophoral cartilage hoods typical of a cistiscid radula; 11: teeth details of double radula. 12, 13. Holotype of *Gibberula elvirae* n. sp. from Salamanza, São Vicente (PEICV). 12: shell (4.8 x 3.0 mm); 13: radula.
(Página derecha) Figuras 5-13. Conchas y rádulas de especies de Gibberula *de las islas de Cabo Verde. 5, 6.* Gibberula rauli, *Salamanza, São Vicente (PEICV). 5: conchas (2,2 y 2,1 mm); 6: rádula. 7-11.* Gibberula rolani. *7: concha de Sal Rei, Boavista (PEICV) (5,1 mm); 8: concha de Rigona, Sal (PEICV) (5,0 mm); 9: rádula de Sal Rei, Boavista (PEICV); 10, 11: rádula teratológica doble de Sal Rei, Boavista (PEICV); 10: rádula doble mostrando la forma de capucha del cartílago odontoforal, típica de una rádula de cistíscido; 11: detalle de los dientes de la rádula doble. 12, 13. Holotipo de* Gibberula elvirae *n. sp. de Salamanza, São Vicente (PEICV). 12: concha (4,8 x 3,0 mm); 13: rádula.*


5
6
10 µm
7
9
20 µm
10
100 µm
8
11
20 µm
12
13
20 µm

The radula is described and figured here for the first time (Fig. 6). Radular teeth have an arched form with a central cusp prominent but narrower than some lateral cusps. On each side of the central cusp there is a small one, followed by three lateral cusps, the first one large and strong, and then two external ones, smaller. There are 9 cusps in total. The teeth are 0.017 mm width. As the shell length of the specimen dissected for radular study is 2.0 mm, the "shell length/tooth width" ratio (L/Wr) is 118.

Habitat: This species lives in the upper zone of the sublittoral, between 1 and 5 meters depth, on rocky bottoms with sand and algae.

Distribution: An endemic species from the Cape Verde Islands. Rolán (2005) stated that *G. rauli* is known from the entire archipelago. The islands reported in the bibliography are: Sal (type locality at Rabo de Junco Beach), Boavista, Maio, Santiago and São Vicente. In the present work it is cited also from Brava Island. *Gibberula philippii* is a Mediterranean species (Gofas, 1990) erroneously cited from the Cape Verde Islands by García-Talavera and Bacallado (1979).

Gibberula rolani Cossignani and Cecalupo, 2005 (Figs. 7, 8, 9, 10, 11 and 15)

Gibberula sp. 1: Rolán, 2005; p. 148, only part (Figs. 643-644) (endemic from the Cape Verde Islands).
Gibberula sp. 2: Rolán, 2005; p. 148, (Fig. 645) (endemic from the Cape Verde Islands).
Gibberula rolani Cossignani and Cecalupo, 2005: p. 6-7, 6 Figs. (Mordeira in Sal Island, Cape Verde Archipelago).

Other references (doubtful: could also be *G. elvirae* or *G. lucia*):
?*Gibberula miliaria* (Linnaeus, 1758): Rochebrune, 1881b; p. 293 (Porto-Praya in Santiago Island, Cape Verde Archipelago).
?*Gibberula oryza* Lamarck, 1822: Dautzenberg, 1910; p. 43-44 (Cape Verde Archipelago).
?*Gibberula miliaria* (Linnaeus, 1758): Melvill and Standen, 1913: p. 342 (São Vicente, Cape Verde Archipelago).
?*Persicula miliaria* (Linnaeus, 1758): Saunders, 1977; p. 14 (Matiota in São Vicente and Palmeira in Sal Island, Cape Verde Archipelago).
?*Persicula miliaria* (Monterosato) [sic]: García-Talavera and Bacallado, 1979; p. 207 (Mindelo and Gatas in São Vicente Island and Praia in Santiago Island, Cape Verde Archipelago).
?*Gibberula miliaria* (Linnaeus, 1758): Cosel, 1982a; p. 20 (São Vicente, Sal and Santiago Islands, Cape Verde Archipelago).
?*Gibberula miliaria* (Linnaeus, 1758): Cosel, 1982c; p. 57 (Cape Verde Archipelago).

Material studied (all from Cape Verde Islands): Boavista Island: Sal Rei, 6 sp. + 1 juv. + 1 juv. + 1 juv. (UAM). Derrubado, 2 sp. + 1 juv (ER). Sal Island: without locality, 6 sp. + 1 sp. + 1 sp. (IIT). Palmeira, 1 sp. + 1 sp. + 2 sp. (UAM). Ponta Preta, 10 sp. + 9 juv. (ER). Palhona, 6 sp. + 4 sp. + 4 sp. + 4 juv. (ER). Rabo de Junco, 27 sp. + 10 juv. (ER). Mordeira, 5 sp. + 1 sp. (ER). Monte Leste, 8 sp. + 3 sp. (ER). Santa María, 1 sp. (UAM). Rigona, 1 sp. + 1 sp. (UAM), 6 sp. + 1 juv. (ER). Algodoeiro, 4 sp. (ER). Fiura, 1 sp. (UAM). ?Brava Island: Baia Pedrinha, 1 sp. (ER).

Description: The species description by Cossignani and Cecalupo (2005) is basically correct, but based only on the shell. This is pyriform, narrow in the anterior end with a broad and rounded body whorl. There are 5-6 plaits in the columella, decreasing in size posteriorly, and 14-18 small denticles on the inner side of the outer lip. In general the shell has a dark brown sutural band, not always present. Several specimens are plain white (Fig. 7) or a pale yellow, and other shells have two or three spirals bands of a very pale brown (Fig. 8). Some specimens have one broad spiral and brown band in the central part of the body whorl, a result of the fusion of both anterior pigmented lines.

The animal, described here for the first time (Fig. 15, from Boavista Island material) is active and slithers fast on the substratum with the foot, which is larger than the shell when totally extended. The foot is ovate in the metapodium and truncated in the propodium, translucent-white with peripheral orange lines and patches, and a conspicuous central line on the posterior end (Fig. 15). Some specimens do not have the metapodium pigmented, but have orange lines in the propodium. The head is small with a central split. There is one orange line on each side of the head from the inner part of the eyes to the anterior end of the snout. The tentacles are short, with a small and central band, also orange. The siphon is small, of a pale yellow colour. The inner mantle, that can be observed by transparency, is also very variable, dark with white lobes, orange with white patches, or clear with dark or orange dots.

The radula is described and figured here for the first time (Fig. 9, from Boavista Island material). Radular teeth were studied from two specimens. The teeth have an arched form with a prominent central cusp. There are on each side of the central cusp a small one (not always present) and 4 (3 or 5 in some cases) strong lateral cusps (there are 9-10 cusps in total). The same pattern of cusps are observed every three teeth, so that two adjacent teeth never have the same cusps, and the lateral cusps of similar length do not match in the same position. A teratological specimen was observed with two complete radulae in the same bucal bulb (Figs. 10-11), one of them placed over the other. The teeth of both radulae are similar to that previously described for a normal specimen. The average tooth width is 0.026 mm. As the average shell length of the specimens is 5.0 mm, the "shell length/tooth width" ratio (L/Wr) for this species is 192.

Habitat: This species lives in the upper sublittoral area, between 1 and 5 m depth, where it was observed under stones on rocky bottoms with sand.

Distribution: G. rolani is an endemic species of the Cape Verde Islands. We have found this species only on Sal and Boavista islands, where it is frequent. We studied also a single specimen from Brava Island that probably belongs to this species, with a similar form and 2 spiral bands of pale brown, one central and another on the base. Some of the references of *Gibberula miliaria* from the Cape Verde Islands (considered here as corresponding to *G. rolani*) cited other islands in its distribution, such as Santiago (ROCHEBRUNE, 1881b; COSEL, 1982a) and São Vicente (SAUNDERS, 1977; GARCÍA-TALAVERA AND BACALLADO, 1979; COSEL, 1982a). If *G. rolani* really lives on Santiago and São Vicente, a fact that should be confirmed with new material, the species would achieve a distribution throughout all the island groups of the archipelago.

Discussion: The description of this species by COSSIGNANI AND CECALUPO (2005) was made immediately (November 2005) after the publication in April of the same year of the book by ROLÁN (2005) on the malacological fauna of the Cape Verde Archipelago. ROLÁN (2005) included two *Gibberula* species without specific names (sp. 1 and sp. 2, on page 148), stating that they were in course of description. The hasty description of *Gibberula rolani* by COSSIGNANI AND CECALUPO (2005) disregards the ethical recommendation of the International code of Zoological Nomenclature because they knew the situation regarding the case and stated that their new species was present in the book by ROLÁN (2005) as "*Gibberula* sp. 1 (Figs. 643-644, 776) and *Gibberula* sp. 2 (Fig. 645) pag. 148".

It is most probably this species which has been misidentified as *Gibberula miliaria* (Linnaeus, 1758) by several authors, but *G. miliaria* lives only in the Mediterranean Sea (GOFAS, 1990). There are obvious differences in the pigmentation pattern between both species, particularly on the foot, where *G. rolani* has a clearly defined pattern with peripheral orange lines and patches. Also, the head of *G. rolani* has single

Figures 14-16. Live animals of *Gibberula* species from Cape Verde Islands. 14: *Gibberula rauli*, Salamanza, São Vicente (PEICV) (2.2 mm); 15: *Gibberula rolani*, Sal Rei, Boavista (PEICV) (5.0 mm); 16: holotype of *Gibberula elvirae* n. sp., Salamanza, São Vicente (PEICV) (4.8 mm).
Figuras 14-16. Animales vivos de especies de Gibberula *de las islas de Cabo Verde. 14:* Gibberula rauli, *Salamanza, São Vicente (PEICV) (2,2 mm); 15:* Gibberula rolani, *Sal Rei, Boavista (PEICV) (5,0 mm); 16: holotipo de* Gibberula elvirae *n. sp. Salamanza, São Vicente (PEICV) (4,8 mm).*

orange lines and a small band in the tentacles, whereas in *G. miliaria* the foot and head patterns are more elaborate, with different colours and small dots (Coovert, 1987; Gofas, 1990). The radula of *G. miliaria* was studied by Bandel (1984, Fig. 297: as *Persicula miliaria*, from Banyuls-sur-Mer, France, Mediterranean Sea) and reproduced by Coovert (1989, Fig. 19). The teeth of *G. rolani* are similar to those of *G. miliaria*, but in the former the lateral cusps are stronger than in the latter species. Also, the teeth of *G. rolani* have 8-9 cusps against 9-11 in *G. miliaria*.

About the teratological radulae studied (Figs. 10-11) it seems that in this strange specimen there are two radular sacs, instead of one, but only a pair of odontophoral cartilage hoods (Fig. 10), characteristic of the "cysticid radula", so called by Coovert and Coovert (1995). There is no information of a similar case known in the marginelliform gastropods (Coovert and Coovert, 1995).

Dautzenberg (1910) included the Cape Verde Islands in the distribution of the species *Gibberula oryza*, but this species lives only on the continental African coasts from Senegal to the Strait of Gibraltar (Gofas, 1990). Some shell patterns of *G. rolani*, like those with a broad band remind of the neotype of *G. oryza* figured by Gofas (1990, Fig. 2), or shells without bands, which look like specimens of *G. oryza* from Ceuta (Fig. 3 in Gofas, 1990). However, the shell of *G. rolani* is smaller (up to 5 mm length) than that of *G. oryza* (up to 8 mm length). The colour pattern of the animal is also different between these two species; *G. rolani* has only orange lines and patches,

Figures 17-18. Live animals of *Gibberula* species. 17: *Gibberula oryza*, Punta Carnero, Cádiz, Spain (7 mm); 18: holotype of *Gibberula elvirae* n. sp., Salamanza, São Vicente (PEICV) (4.8 mm).

Figuras 17-18. Animales vivos de especies de Gibberula. *17:* Gibberula oryza, *Punta Carnero, Cádiz, España (7 mm); 18: holotipo de* Gibberula elvirae *n. sp. Salamanza, São Vicente (PEICV) (4,8 mm).*

restricted in general to the pedal margin of the foot, while in *G. oryza* the pigmentation pattern is outspread, with orange, yellow and violet small dots over all the foot (GOFAS, 1990: Pl. 1, Figs. a-a'; see also Fig. 17 in the present paper). The radula of *G. oryza* of a specimen from Ceuta was studied by GOFAS (1990, Fig. 1). The arched form of the teeth and the number of cusps are very similar between *G. rolani* and *G. oryza* (9-10 and 11 cusps, respectively), but in the first species the tooth width is significantly smaller (0.026 mm) than that of the second (0.038 mm). The "shell length/tooth width" ratio (L/Wr) is similar in both species, 192 and 187 respectively, but the length shell of the first species is 5 mm, while in *G. oryza* it is more or less 7 mm (GOFAS, 1990 did not state the shell length of the specimen dissected for obtention of the radula figured).

Gibberula elvirae n. sp. (Figs. 12, 13, 16 and 18)

Gibberula sp. 1: Rolán, 2005; p. 148, only part (Fig. 776) (endemic from Cape Verde Island).

Other references (doubtful):
?*Gibberula oryza* Lamarck, 1822: Dautzenberg, 1910; p. 43-44 (Cape Verde Archipelago).
?*Gibberula miliaria* (Linnaeus, 1758): Melvill and Standen, 1913: p. 342 (São Vicente, Cape Verde Archipelago).
?*Persicula miliaria* (Linnaeus, 1758): Saunders, 1977; p. 14 (Matiota in São Vicente and Palmeira in Sal Island, Cape Verde Archipelago).
?*Persicula miliaria* (Monterosato) [sic]: García-Talavera and Bacallado, 1979; p. 207 (Mindelo and Gatas in São Vicente Island and Praia in Santiago Island, Cape Verde Archipelago).
?*Gibberula miliaria* (Linnaeus, 1758): Cosel, 1982a; p. 20 (São Vicente, Sal and Santiago Islands, Cape Verde Archipelago).

Type material: Holotype, specimen 4.8 x 3.0 mm, from Salamanza, São Vicente (Cape Verde Islands), from a lot of one specimen (UAM no. 229) collected on 20-VIII-1985 by PEICV (deposited in MNCN, no. 15.05/60007); Paratypes 1 and 2 (the latest with the siphonal canal broken) from Baia do Calhau, São Vicente, from a lot of five specimens (two broken) (MNHN, Rudo von Cosel Coll., 21-XII-1978) (both deposited in MNHN).
Other material studied: ?Brava Island: Baia Pedrinha, 3 sp. (ER).
Type locality: Salamanza, São Vicente, 1 m depth.
Etymology: The species is dedicated to my daughter Elvira Moreno Martín 11 years old, for her constant effort, sensitivity and enthusiasm without limits.

Description: The shell is oval-cylindrical, quite elongate, with the body whorl covering almost all the previous spirals. There are 6-7 plaits in the columella, decreasing in size adapically. The outher lip goes from the sutural area to the siphonal canal, is swollen and has 15-16 well defined denticles on the inner side. The surface is smooth and brilliant and somewhat translucent, so that the internal mantle can be seen by transparency. The protoconch is paucispiral like in all marginelliform gastropods, and the adult shell has approximately 2.5 whorls. The aperture is narrow and elongated, and it has in its anterior part a wide siphonal canal. The shell colour seems very constant, with four brown bands, plus one in a subsutural position. These four bands, more or less equidistant, are narrow but well contrasted, except the second one (numbered from de suture) which is broader than the others, and constitutes the central band very characteristic of the species.

The animal is active, with the foot longer than the shell when it is completely extended. The foot is truncated in the anterior part and rounded in its rear end. The head is small, divided into two parts with a pair of very short tentacles. The eyes are near the base of the tentacles. The siphon, placed on the head, is short and wide. The pigmentation pattern is very typical, with intense colours: white, black and orange (Figs. 16 and 18). The head is black, with two yellow specks in the center and two orange ones on the snout. Behind each eye there is an orange speck, as on the end of every tentacle. The siphon has black spots and the end is bordered with orange. The foot presents lateral and radial black bands, which reach the pedal border, whereas in the anterior and posterior parts they end before reaching the rim. The margin of the foot has a thin orange line, which is continued on the propodium or anterior part, and intermittent on the central part and end of the metapodium. On the propodium and the posterior metapodium numerous orange dots exist. The internal mantle, seen by transparency, is black in colour with large white, irregular, but very definite patches. The only animal observed was the holotype.

The radula has approximately 150 tooth lines (data from the only animal

studied, the holotype). The teeth are 0.036 mm width (Fig. 13). As the shell length of the specimen dissected for radular study is 4.8 mm, the "shell length/tooth width" ratio (L/Wr) is 133. The teeth are arched and have a more prominent central cusp with 4-5 minor denticles on each side (10-11 cusps in total). The central cusp has a broad base and is blunt. The adjacent cusps to the central one (1 or 2 in number) are smaller that the other lateral denticles. Every 3 teeth, approximately, the same pattern of denticulation is observed. There are never two identical contiguous teeth and the lateral cusps of equal size do not coincide with the same line.

Habitat: This species lives in the upper sublittoral area, between 1 and 2 m depth, on a rocky bottom with algae.

Distribution: Gibberula elvirae n. sp. is an endemic species of the Cape Verde Islands. We have found this species with certainty only on São Vicente Island, where seems to be limited to the North-East coast. A lot of 3 specimens from the island of Brava (Baia Pedrinha) probably belongs to this species, considering the presence of 4 bands on the shell as described previously. The species has not been found on the eastern islands, such as Sal and Boavista, in spite of the numerous samples obtained from both.

Discussion: *Gibberula elvirae* n. sp. is different from any other species known in this genus, both for the coloration and shape of the shell, and for the pigmentation pattern of the animal, including the other species with similar length shell that live in the Cape Verde Islands: *G. lucia* and *G. rolani*. The central expanded band of the shell recalls certain patterns of *G. oryza*, but the latter does not possess the thin basal bands, next to the siphonal canal and to the suture, respectively. As stated by GOFAS (1990), when the shells of *G. oryza* have a pattern with spiral pigmentation, they can show either a broad and central band like the neotype, or two broad and parallel bands in a central position (his figures 2 and 4, respectively). However, the shell of *G. elvirae* n. sp. has up to 4 bands, and only the second (from the suture) is broader than the others. The length and general shape of the shell is also different; *G. elvirae* is smaller (less than 5 mm) and of cylindrical shape, while *G. oryza* is larger (up to 8 mm) and piriform.

The animal of *G. elvirae* n. sp. was illustrated by ROLÁN (2005, Fig. 776) as *Gibberula* sp. 2 (actually that specimen is the holotype designated here and that photograph the same image reproduced here in Figure 18). The colour pattern of the animal of *G. elvirae* is different from that of *G. oryza* shown by GOFAS (1990: Pl. 1, Figs. a-a') and in the present paper (Fig. 17), in having: 1) several black patches on the foot, on the head and on the siphon, 2) the orange dots of the propodium arranged forming a well defined line, and 3) the tentacles with a broad orange band.

Like for the previous species, the "V"-shape of the teeth and the number of cusps are very similar between *G. elvirae* n. sp. and *G. oryza* (10-11 and 11 cusps, respectively). Also, the tooth width is similar between both species (0.036 and 0.038 mm, respectively), but in the first species the "shell length/tooth width" ratio (L/Wr) is 133 and in *G. oryza* is 187, because the shell in the last species is larger. GOFAS (1990) did not state the shell length of the dissected specimen used to obtain the figured radula, and here it is assumed to be of 7 mm, an average of the specimens mentioned by the same author from the Strait of Gibraltar.

Other species described from the Cape Verde Islands

Gibberula jousseaumi Rochebrune, 1881, described with type locality in Porto Praia, Santiago Island, was cited later as *Marginella jousseaumi* by BURNAY AND MONTEIRO (1977), as *Gibberula jousseaumi* by COSEL (1982a), and as *Persicula jousseaumi by* GUERREIRO AND REINER (2000), all of them with material

from Sal Island. However, this name was considered as a subjective synonym of *Volvarina sauliae* (Sowerby, 1846) by Moreno and Burnay (1999) in their revision of the genus *Volvarina* in the Cape Verde Islands. *Volvarina sauliae* has a shell that resembles a *Gibberula*, but has a typical radula of the genus *Volvarina*, with rectangular and "comblike" shaped teeth, flat and multicusped (type 6 following Coover, 1989), while the radula of genus *Gibberula* is of type 3 (according to the same author), with teeth strongly concave in the basal edge, "V"-shaped and relatively few cusps.

The taxon *Gibberula rachmaninovi* Kellner, 2003, was introduced recently in a very poor description based only on a shell from Sal Island, without animal and radula data. Rolán (2005) in his book on the mollusks from the Cape Verde Islands considers as a valid species *Volvarina sauliae* (p. 146, Figs 635-636, from Furna, Brava Island, which is the same specimen shown by Moreno and Burnay, 1999, Fig. 37, actually coming from Baia Pedrinha in the same island), and also *Gibberula rachmaninovi* (p. 148, Figs. 1193-1194, holotype from Santa Maria, Sal Island). Moreno and Burnay (1999: p. 113 and Fig 35) designated and figured a neotype of *Volvarina sauliae* to stabilize the nomenclature of this species. The holotype of *G. rachmaninovi* matches the neotype of *V. sauliae* in all respects, and therefore the first name is considered here a synonym of *Volvarina sauliae* (Sowerby, 1846).

DISCUSSION

The genus *Gibberula* is represented in the Cape Verde Archipelago by four species, three previously described (*Gibberula lucia* Jousseaume, 1877; *Gibberula rauli* Fernandes, 1987; and *Gibberula rolani* Cossignani and Cecalupo, 2005), and the new species described here *Gibberula elvirae* n. sp.

Gibberula jousseaumi Rochebrune, 1881, and *Gibberula rachmaninovi* Kellner, 2003, are considered here synonyms of *Volvarina sauliae* (Sowerby, 1846). The names of the Mediterranean species *Gibberula miliaria* (Linnaeus, 1758) and *G. philippii* (Monterosato, 1878) are erroneously included in the Cape Verde Islands because these species are not present in the archipelago.

Among the *Gibberula* species that live in Cape Verde Islands, there are two clearly differentiated groups, which are equivalent to those already known from the Mediterranean, where Gofas (1990) speaks about the "group of *G. oryza*" and the "group of *G. philippii*", based on shell length, shell transparency, pigmentation patterns of the animal and most frequent colours. In Cape Verde waters, one group is constituted by "large" species (for the dimensions of the genus), of 3.5-5 mm long (as *G. lucia*, *G. rolani* and *G. elvirae* n. sp.), whereas another group is represented by only one "small" species, of approximately 2 mm long (*G. rauli*). The number of *Gibberula* species (four, in the present paper) present in the Cape Verde Archipelago is smaller than that of *Volvarina* species (nine, in Moreno and Burnay, 1999), a genus of the family Marginellidae. It is curious that the opposite happens in the Mediterranean, where there are more species of *Gibberula* (also nine, according to Gofas, 1990), than of *Volvarina* (only one, according to Gofas, 1989a). So, in the North Eastern Atlantic Ocean the diversity of *Volvarina* species is highest in warm waters, and specially in the Cape Verde Islands, while the diversity of *Gibberula* species is highest along temperate coasts, principally in the Mediterranean Sea. Also along the Angolan coast, in the southeast Atlantic Ocean, there is a higher diversity of species for the genus *Gibberula*, with at least 11 described species (Gofas, 1989b).

The radular teeth, their size, shape and number of cusps, are also important to discriminate species in the genus *Gibberula*. Among the studied species the smallest radula is that of *G. rauli*, with

only 0.017 mm tooth width. However, the "shell length/tooth width" ratio (L/Wr) is 118, exactly the lowest values cited for the genus by COOVERT AND COOVERT (1995). This means that the radula is the largest in comparison to the shell among the *Gibberula* species known. On the contrary the radula of *G. rolani*, although larger (average of 0.026 mm tooth width), is proportionally smaller in relation to the animal, with a "shell length/tooth width" ratio (L/Wr) of 192. The largest radula of the studied species is that of *G. elvirae* n. sp. (0.036 mm tooth width), almost the same size as that of *G. oryza*. Nevertheless, the height of the shell *of G. elvirae* n. sp. (up to 5 mm) is clearly smaller than that of *G. oryza* (up to 8 mm), and therefore, the "shell length/tooth width" ratio (L/Wr) in this species is smaller (133) that that of the other species mentioned: *G. rolani* and *G. oryza* (with L/Wr ratio of 192 and 187, respectively).

All species studied here have a restricted distribution area and are endemic to the Cape Verde Islands, except *G. lucia* Jousseaume, 1877, cited also from Dakar, Senegal (KNUDSEN, 1956; PIN AND BOYER, 1995), the closest point of the African continent to the Cape Verde Islands. There are relatively few data about the distribution of the species within the Archipelago, in part due to the difficulty in determining the species in the absence of information on the animal colour pattern and radular data. Also, the majority of previous publications that included *Gibberula* species from Cape Verde Islands cited names of Mediterranean species (*G. miliaria* and *G. philippii*), or from the continental coasts (as *G. oryza*) and therefore these records are difficult to assign to the species now considered valid in the Archipelago.

The species that has a wider distribution is *G. rauli*, that lives on Sal (type locality), Boavista, Maio, São Vicente, Santiago and Brava. Accordingo to ROLÁN (1991, on the genus *Conus*), and MORENO AND BURNAY (1999, on the genus *Volvarina*), there are several natural barriers between islands in the Cape Verde Archipelago. The main barrier divides the Archipelago into two groups, that of the South East (including Sal, Boavista, Maio, Santiago, Fogo and Brava) and that of the North West (including São Nicolau, Santa Luzia, São Vicente and Santo Antão). In the first group there are also important barriers between Sal and Boavista-Maio, and between Santiago-Fogo-Brava and Maio-Boavista. So, *G. rauli* is present in all the groups and subgroups of islands in the Archipelago, and probably lives on all the islands. *Gibberula rolani*, described from Sal is here confirmed from Boavista, where it is common. A single specimen from Brava studied here, considered with some doubts as belonging to this species, might indicate its presence in the southern group of islands. The old material (from publications before 1987) that cited the Mediterranean species *G. miliaria* could correspond to *G. rolani*, with doubts because they might correspond also to other species. These distribution data include also São Vicente of the North group of islands. If the presence of *G. rolani* was confirmed in Brava and São Vicente, the distribution of the species would include all groups and important sub-groups of islands. Nevertheless, for the moment, with confirmed information, its distribution is restricted to Sal and Boavista, the easternmost islands which are closest to the African coast. *Gibberula elvirae* n. sp. is described here only from São Vicente specimens which is the type locality. There is a small lot of 3 specimens from Brava (ER) that have a very pale coloured shell, but with a pattern similar to that of the type material of *G. elvirae* n. sp. For the moment, this new species could be considered as endemic to São Vicente, with reservations, pending verification of the small lot of 3 specimens from Brava or its presence on other islands. Finally, *G. lucia*, the first species described from Cape Verde Islands, is the only one that we can consider to be not endemic, being found also in Senegal. There were no data of this species in the Cape Verde Islands since its description and all along the XIX and XX centuries, whereas on the contrary, there

was good material from Senegal. In the present work a single specimen collected at Santiago (AO), confirms the presence of the species in the Cape Verde Islands, if there was any doubt about the correct origin of the material studied by Jousseaume.

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Alvania garrafensis Peñas & Rolán 2008 (Gastropoda: Rossoidae) from Croatian waters

Alvania garrafensis Peñas & Rolán 2008 (Gastropoda: Rossoidae) en aguas croatas

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ABSTRACT

We report on the presence of numerous specimens of *Alvania garrafensis* Peñas & Rolán 2008 from shell grit dived in shallow waters near several islands of the Quarnero Gulf, North Adriatic Sea, Croatia. The species was up to now known only from the Garraf littoral, Barcelona, East Spain and the present records greatly extend its geographical distribution. Hypotheses that could explain such a large range extension are considered.

RESUMEN

Se documenta el registro de numerosos ejemplares de *Alvania garrafensis* Peñas y Rolán 2008 en cascajos conchíferos recolectados por buceo en aguas someras de varias islas del golfo Quarnero, norte del mar Adriático, Croacia. La especie se conocía hasta la fecha sólo en el litoral del Garraf, Barcelona, este de España, así que la nueva cita amplía considerablemente su distribución geográfica. Se adelantan hipótesis que podrían explicar una ampliación tan considerable.

INTRODUCTION

Alvania garrafensis Peñas & Rolán 2008 was described on a few specimens trawled at 90 m depth off Cubelles, west end of Garraf, after which the species was named. Its known distribution was hitherto limited to the type locality only. A localized distribution has to be expected since the species has a shell protoconch of 1,5 whorls, suggesting its non – planktonic development and hence not a wide geographical range (SCHELTEMA 1978; 1986). In this respect our records from Croatia seem quite strange and surely need to be at least pointed out and, if possible, understood.

MATERIALS AND METHODS

Most of the *A. garrafensis* specimens we examined were found dead in shell grit obtained through diving during late Summer 2008 at various stations near the islands of Krk and Prvic, Quarnero Gulf, Croatia, at 35/50 m depth. The material was picked from sandy or muddy bottoms below the coralliferous slopes which in a few steps connect the rocky coast to the bottom. A quantity of ~ 15 litres of shell grit was collected altogether. From this material ~ 340 shells of *A. garrafensis* were extracted;

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this species was the commonest *Alvania* in the sorted material.

This large amount of shells were distributed as follows: Krk, Sokol Point 45m 120 shells; Krk, loc. Baska 38m 18 sh.; Prvic, Kita Bay 45m ~ 100 sh.; Prvic, Gladni Potok Bay 50m 105 sh.

We could also examine two other samples, courtesy of Peter Sossi, Trieste: Prvic, 21m 6 sh; Plavnik, 40m 4 sh.

TAXONOMY

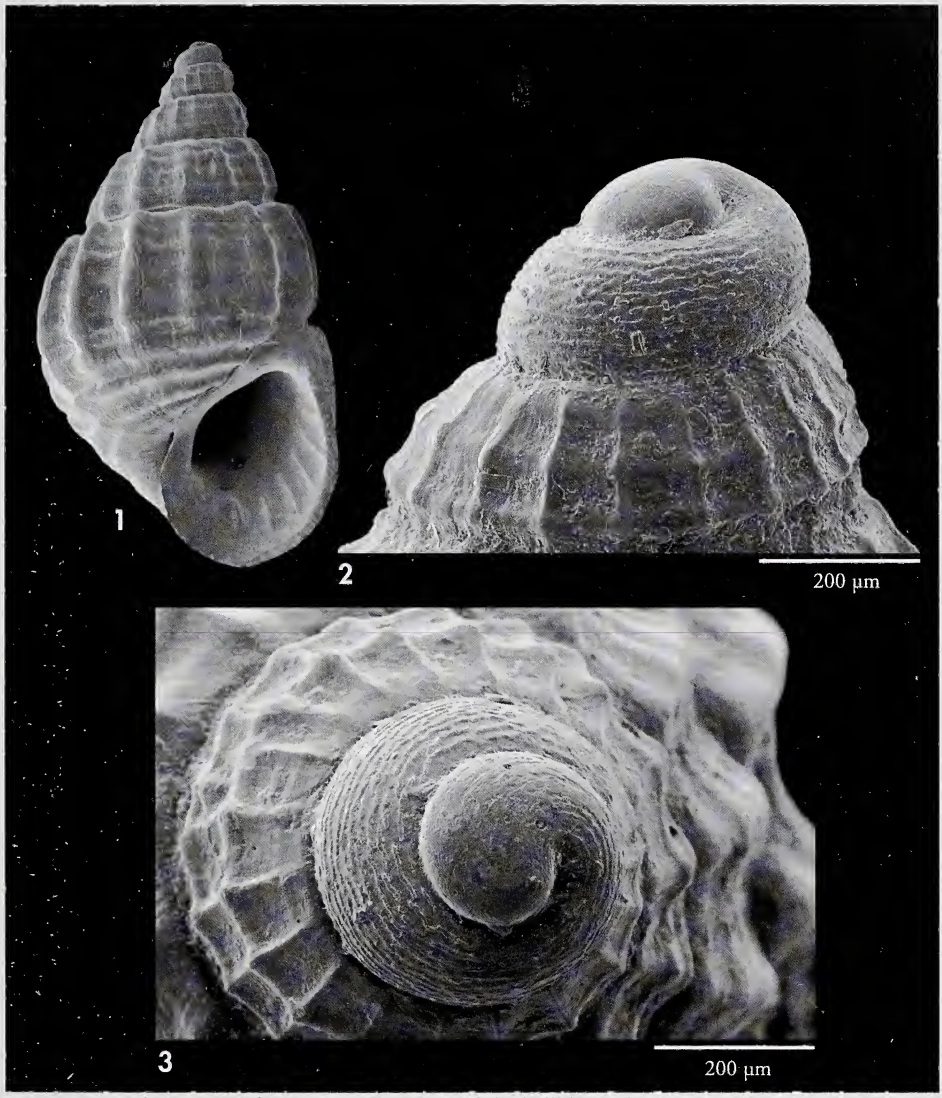
COENOGASTROPODA Cox, 1960
RISSOIDAE Gray, 1847
Alvania Risso 1826

Alvania garrafensis Peñas & Rolán 2008

Figures 1-6 show all the features needed to compare our specimens with *A. garrafensis*. Beyond the general shape, we point out the 1.5 whorls, ~ 400 µm wide shell protoconch with its very characteristic spiral sculpture of 12 more or less fragmented threads; a body whorl a bit less than 70% of the total height; an axial sculpture of orthocline cords interrupted at the base margin; a weak spiral sculpture of 7 cords on the body whorl, 4 between the two sutures and 3 on the base. All these features fit nicely with the holotype original description and images. This however has only three whorls at 2,8 mm height, compared with four whorls at 3,5-4 mm height of our Croatian specimens. We thus conclude that the Spanish original material contained only shells that were slightly immature. In our opinion this fact can accommodate a difference we observed between the two: while our full grown specimens show lyrae all over the lip internal margin, only 2-3 of these are observed in the holotype shell near the lowest part of the lip. We consider that a minor difference and we are confident that our Croatian specimens have to be assigned to *A. garrafensis*. We moreover sent a few of our specimens to Dr. Emilio Rolan, who produced the SEM images of figs. 1-3 and endorsed our assignment. A hint to this possible assignment was also present in a discussion topic on the "Natura Mediterraneo" Italian online discussion forum <www.naturamediterraneo.com>, accessed November 2011.

We nevertheless compared our specimens with the two species *Alvania consociella* Monterosato 1884 and *Alvania disparilis* Monterosato 1890. As for the first we based our observations on personal material from our collections and on images from the literature (GIANNUZZI SAVELLI, PUSATERI, PALMERI & EBREO, 1997; SCAPERROTTA, BARTOLINI & BOGI, 2011). For the second we obtained a photo of a specimen 3,6 mm high, from the Monterosato collection in Rome Zoological Museum (ZMR), courtesy of A. Pierullo. This photo enabled a comparison of this species with our Croatian specimens.

Alvania consociella has deep and canaliculated sutures, almost flat whorls, more numerous spiral chords which form nodules crossing the axial ones, giving a nodulose look to the shell shape; it often has few spirals,which are white on a darker background; its protoconch shows a papillae sculpture that is quite different from that of *A.garrafensis*. The photo of *A. disparilis* we saw shows a shell shape more squat than *A. garrafensis* (height to width ratio ~ 1,6 versus 1,9 in Croatian specimens), with rounded whorls and a rounded aperture; the sutures are deep and canaliculated (unlike in *garrafensis*); the thin orthocline axial chords are much narrower than their interspaces (wider in *garrafensis*) and more numerous; the spiral chords are more numerous than in *garrafensis*, as thin as the axial ones, and the axial to spiral crossing forms a regular squared reticule (totally absent in *A. garrafensis*); finally a few (3-4) thin, but well

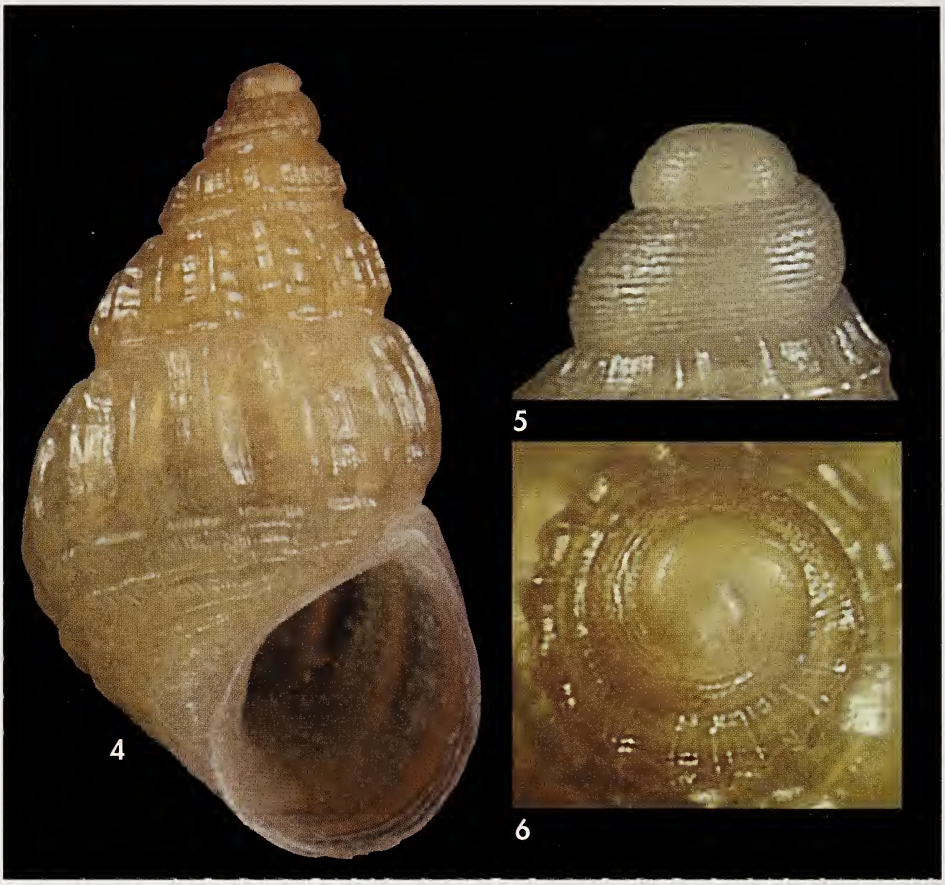


Figures 1-3. *Alvania garrafensis* SEM images. 1: adult shell 4 mm high, Krk Island, 45 m; 2: protoconch of the same specimen, side view; 3: protoconch of the same specimen, apical view.
Figuras 1-3. Alvania garrafensis *imágenes de MEB. 1: concha adulta de 4 mm de alto, isla de Krk, 45 m; 2: protoconcha del mismo ejemplar, vista lateral; 3: protoconcha del mismo ejemplar, vista apical.*

raised and marked smooth spiral chords are evident on the base. All these differences are clearly seen comparing Figure 7 to Figures 1-6.

DISCUSSION

Alvania garrafensis is apparently much commoner and widespread in Croatian waters then in the type locality. It was found in large numbers and in many places in Croatia, always in the depth range 25-50 m, while in the case



Figures 4-6. *Alvania garrafensis.* 4: specimen from Prvic, 50 m, 4 mm high; 5, 6: different views of the protoconch of the same specimen, greatly enlarged.
Figuras 4-6. Alvania garrafensis. *4: ejemplar de Prvic, 50 m, 4 mm de alto; 5, 6: diferentes vistas de la protoconcha del mismo ejemplar, a mayor aumento.*

of Garraf only a few specimens coming from a single and much deeper locality (90 m.) were found.

Moreover to our knowledge the species has never been recorded in any locality intermediate between Garraf and Croatia, e.g. French or Italian coasts, although it may well have been overlooked due to its quite recent description.

A possible explanation would be to regard (Rolan, private communication) *A. garrafensis* as a native species in Croatian waters, arrived to Garraf via some "man assisted" transportation mechanism, for instance with the trade of *Ostrea edulis* from the North Adriatic Sea to the Iberian Peninsula. A different opinion (from A. Peñas, private communication) is that maybe *A. garrafensis* is widely present in the West Mediterranean, but yet unsampled in most areas in deep waters; moreover to his knowledge there is no *Ostrea edulis* import in the type location area. We think that the hypothesis of a Croatian origin for the species arrived in Garraf via some "man assisted" transportation mechanism seems very unlikely and that the hypothesis of a hitherto overlooked species is to be preferred.

We conclude that the problem of the geographical distribution of *A. garrafen-*

Figure 7. *Alvania disparilis,* Palermo, 3.6 mm, specimen in Monterosato collection, Zoological Museum of Rome.
Figura 7. Alvania disparilis, *Palermo, 3,6 mm, ejemplar en la colección Monterosato, Museo Zoológico de Roma.*

sis is unclear as yet and its full understanding needs some further research in regions intermediate between the Garraf area and the Adriatic Sea, where it seems well established.

ACKNOWLEDGEMENTS

This paper wouldn't have been possible without the generous help of Dr. Emilio Rolan, Vigo, Spain, who prepared the SEM images of our shells, confirmed our species assignment, shared with us his opinions on the species geographical distribution and. revised our paper We thank him a lot for that. We thank also Peter Sossi, Trieste, for letting us examine some of his specimens, Mrs. Angela Pierullo, Rome, for providing us with a photo of an *A. disparilis* type specimen and Dr. Massimo Appolloni, responsible for the ZMR malacological collection for permission to publish this image. We finally thank an anonymous referee who suggested a few relevant changes to the paper.

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A review of species-limits in some *Cryptazeca* (Gastropoda: Azecidae)

Reconsideración de los límites entre especies en *Cryptazeca* (Gastropoda: Azecidae)

David T. HOLYOAK and Geraldine A. HOLYOAK*

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ABSTRACT

Species-limits are reviewed for several taxa in the land-snail genus *Cryptazeca*, based mainly on measurements of shell size and shape. Compared to previous studies, larger samples of shells from more numerous populations were available for analysis. Widely overlapping ranges of variation in shell size and form in *C. monodonta* (from SW. France) and *C. kobelti* (NW. Spain) imply that these allopatric taxa are likely to be conspecific, so the latter name is synonymised with the former. The species lives amongst leaf-litter in moist deciduous woodland. *C. subcylindrica* (SW. France) has shells that are similar to those of some populations of the allopatric and widely variable *C. vasconica* (NW. Spain), hence the latter name is synonymised with the former. The species lives amongst debris in crevices of limestone rocks, sometimes inside caves. An identification key to the species is presented, based on characters of adult shells. The proposed taxonomic changes have implications for the conservation status of the taxa involved, since their current threat status on the IUCN Red List should probably be reduced now that each of the two species recognised as valid has a wider range and more populations known.

RESUMEN

Se realiza una reconsideración de las características que permiten separar especies dentro del género de moluscos terrestres *Cryptazeca*, basados en la forma y medidas de la concha. En comparación con otros estudios previos, este análisis se ha efectuado sobre un mayor número de ejemplares y procedentes de un mayor número de poblaciones. El amplio solapamiento observado en lo concerniente al tamaño y forma de la concha en *C. monodonta* (del SW. de Francia) y *C. kobelti* (NW. España) implica que estos dos taxones alopátricos son muy probablemente conespecíficos, por lo que este último nombre es incluido en la sinonimia del primero. Esta especie vive entre la hojarasca en suelos húmedos de bosques caducifolios. Por otro lado, las conchas de *C. subcylindrica* (SW. Francia) son similares a las de varias poblaciones de la muy variable y alopátrica *C. vasconica* (NW. España), por lo que este último nombre se incluye en la sinonimia de *C. subcylindrica*. Esta especie vive entre los restos vegetales acumulados en fisuras de rocas calizas, y a veces también dentro de cuevas. Se presenta una clave para la identificación de las especies del género, basada en los caracteres conquiológicos de individuos adultos. Los cambios taxonómicos propuestos tienen implicaciones sobre el estatus de conservación de los taxones implicados, de forma que la categoría de amenaza con que figuran en la lista roja de la UICN deberá probablemente ser menor, ya que ambas especies reconocidas como válidas tienen ahora un mayor rango de distribución y se conocen un mayor número de poblaciones.

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INTRODUCTION

The genus *Cryptazeca* De Folin & Bérillon, 1877 comprises small land-snails occurring in woodland, among limestone rocks and in cave habitats in SW. France and parts of NW. Spain. Different authors have regarded them as members of the Ferussaciidae in the superfamily Achatinoidea of the infraorder Sigmurethra (Schileyko, 1976, 1999; Bank, Bouchet, Falkner, Gittenberger, Hausdorf, von Proschwitz and Ripken, 2001; Falkner, Bank and von Proschwitz, 2001; Falkner, Ripken and Falkner, 2002) or Cochlicopidae within the infraorder Orthurethra (Zilch, 1959; Gittenberger, 1983; Gómez and Angulo, 1987, 1990; Gómez, 1990b, 1991). The uncertainty about their wider relationships has been resolved recently by Madeira, Elejalde, Chueca and Gómez (2010) from a phylogenetic study of rRNA sequence data. They demonstrate a sister-group relationship of *Cryptazeca* and *Hypnophila*, both of which are closely allied to *Azeca* (Azecidae), but placed more distant from *Cochlicopa* and far from *Ferussacia*.

The review by Gittenberger (1983) recognised four species of *Cryptazeca*, with two restricted to SW. France in Dept. Pyrénées-Atlantiques (*C. monodonta* (De Folin & Bérillon, 1877), *C. subcylindrica* De Folin & Bérillon, 1877) and two restricted to parts of NW. Spain from Prov. Asturias eastwards to Prov. Navarra (*C. vasconica* (Kobelt, 1894), *C. kobelti* Gittenberger, 1983). Since then two more species have been described from caves in NW. Spain (*C. spelaea* Gómez, 1990a; *C. elongata* Gómez, 1990b). A total of six species has therefore been recognised in recent literature (e.g. Gómez, 1990b; Fauna Europaea Database Project, 2011). Detailed studies of the genital anatomy of *C. monodonta* and *C. vasconica* (Gómez and Angulo, 1987; Gómez, 1991) revealed that they differ significantly in penis structure. Both of the cavernicolous species *C. spelaea* and *C. elongata* also show peculiar features in their genital anatomy (Gómez, 1990a, 1990b), as well as much larger shells than those of all congeners from open habitats. The existence of distinct species is also supported by finds of two pairs of taxa living together at the same localities, *C. monodonta* with *C. subcylindrica* in SW. France (Gittenberger, 1983; at Grotte de Sare: Holyoak and Seddon, 1985) and *C. kobelti* with *C. vasconica* in Spain (S. of Orduña: Gittenberger, 1983; Dance, Holyoak, Seddon and Tattersfield, 1986).

When Gittenberger (1983) wrote his seminal review, most of the specimens available to him were obtained in the nineteenth century. Efforts to refind three of the species were unsuccessful at that time, so his more recent material consisted only of eight shells of *C. vasconica*. However, all of the species were refound in the following two decades, some of them at several localities (Holyoak & Seddon, 1985; Dance *et al.*, 1986; Gómez and Angulo, 1987; Altonaga, Gómez, Martín, Prieto, Puente and Rallo, 1994). The present authors' fieldwork from 2001-2011 has added more specimens and additional localities, but also disclosed populations of *Cryptazeca* that could not be identified to species using the key to shells presented by Gómez (1990b). Our initial suspicions that undescribed species are involved were set aside when fuller studies showed greater variability in shell size and form in the known species than is recognised in existing literature. In particular, the allopatric *C. monodonta* and *C. kobelti* appear to be linked by many intermediate shells and the very variable *C. vasconica* has populations linking it to the allopatric *C. subcylindrica*. This paper therefore reconsiders species-limits in these two species pairs, based on many more specimens than were available for Gittenberger's (1983) review (cf. Table II).

MATERIAL AND METHODS

Field collections by the authors were made by direct searching and by sieving leaf-litter and other debris using nested 2.0 and 0.5 mm mesh sieves to obtain "fines" that were subsequently searched

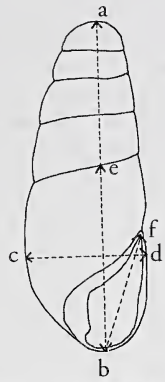

Figure 1. Locations of shell measurements given in Tables I and II. a-b, shell height (SH), c-d, shell breadth (SB), b-e, height of body whorl (BH), b-f, height of aperture (AH).
Figura 1. Representación de las medidas de la concha recogidas en las Tablas I y II. a-b, altura de la concha (SH), c-d, anchura de la concha (SB), b-e, altura de la última vuelta (BH), b-f, altura de la abertura (AH).

at low magnifications using a stereomicroscope. All shells found were retained, to avoid possible bias in favour of large or well preserved specimens. Localities and altitudes were recorded from 2007 onwards using Garmin handheld GPS, accurate to within 10 metres. From 2007 onwards sites were also given consecutive serial numbers (e.g. E153). Habitat notes (including bedrock type and vegetation) and associated Mollusca were recorded at all sites.

Adult snails could readily be distinguished from immatures by the thickened edge to the peristome. Drawings of shells were prepared using a drawing tube on a Meiji RZ series stereomicroscope. Figure 1 shows the locations of measurements of shell height, shell breadth, body-whorl height and aperture height. These measurements were made on adult shells using Infinity Analyze© software on images taken with an Infinity 1 camera on a Meiji RZ series stereomicroscope. The measurements on the images were reproducible to ± < 0.01 mm, but unavoidable slight tilting of the shells almost certainly caused minor additional loss of precision.

Details of the material studied are listed in the Appendix. Specimens reported by HOLYOAK & SEDDON (1985) and DANCE *ET AL.* (1986) were studied on loan from the Dept. of BioSYB of National Museum and Gallery of Wales, Cardiff, U.K. (NMW.Z). Almost all other specimens studied are retained in the Collection of G.A. and D.T. Holyoak.

RESULTS

Measurements of shells are listed in Table I and summarised and compared with those from the literature in Table II. Figure 2 gives drawings of representative shells of each taxon.

AZECIDAE Watson, 1920
Cryptazeca De Folin & Bérillon, 1877
Cryptazeca monodonta (De Folin & Bérillon, 1877)

Azeca monodonta De Folin & Bérillon, 1877, *Bull. Soc. Borda Dax*, 2 (1): 199, pl. [1], figs 1, 2 [Type locality: "Bramepan", St. Pierre-d'Irube SE. of Bayonne, Pyrénées-Atlantiques, France]. See GITTENBERGER & KOSTEN (1983) for bibliographical details.

Table I. Measurements (mm) of shells of *Cryptazeca*. N = number of intact adult shells measured, SH = shell height, SB = shell breadth, BH = body-whorl height, AH = aperture height; see Fig. 1 for locations of measurements.

Tabla I. Dimensiones (mm) de las conchas de Cryptazeca. *N = número de conchas adultas intactas medidas, SH = altura de la concha, SB = anchura de la concha, BH = altura de la última vuelta, AH = altura de la abertura; ver Fig. 1 para la forma en que se han tomado las medidas.*

Species	Region	Locality		N	SH	SB	BH	AH	SH/SB
C. kobelti	Prov. Alava	3 km S. of Orduña	mean	23	3.721	1.734	2.486	1.766	2.147
C. kobelti	Prov. Alava	3 km S. of Orduña	s.d.	23	0.151	0.056	0.099	0.055	0.053
C. kobelti	Prov. Alava	3 km S. of Orduña	min.	23	3.440	1.631	2.259	1.646	2.070
C. kobelti	Prov. Alava	3 km S. of Orduña	max.	23	4.014	1.834	2.702	1.888	2.276
C. kobelti	Prov. Alava	4 km S. of Orduña		1	3.784	1.769	2.397	1.746	2.139
C. kobelti	Prov. Alava	4 km S. of Orduña		1	3.326	1.591	2.221	1.598	2.091
C. kobelti	Prov. Alava	4 km S. of Orduña		1	3.418	1.639	2.201	1.542	2.085
C. kobelti	Prov. Guipúzcoa	E. of Maduriaga		1	3.505	1.652	2.313	1.650	2.122
C. kobelti	Prov. Guipúzcoa	E. of Maduriaga		1	3.575	1.626	2.296	1.620	2.199
C. monodonta	Pyrénées-Atlantiques	Grotte de Sare	mean	56	3.574	1.641	2.406	1.674	2.178
C. monodonta	Pyrénées-Atlantiques	Grotte de Sare	s.d.	56	0.145	0.044	0.102	0.062	0.058
C. monodonta	Pyrénées-Atlantiques	Grotte de Sare	min.	56	3.261	1.532	2.133	1.540	2.065
C. monodonta	Pyrénées-Atlantiques	Grotte de Sare	max.	56	3.938	1.732	2.587	1.809	2.325
C. monodonta	Pyrénées-Atlantiques	1 km SW. of Ustaritz	mean	16	3.301	1.545	2.316	1.611	2.138
C. monodonta	Pyrénées-Atlantiques	1 km SW. of Ustaritz	s.d.	16	0.089	0.040	0.071	0.053	0.053
C. monodonta	Pyrénées-Atlantiques	1 km SW. of Ustaritz	min.	16	3.202	1.470	2.163	1.538	2.046
C. monodonta	Pyrénées-Atlantiques	1 km SW. of Ustaritz	max.	16	3.507	1.603	2.418	1.719	2.242
C. subcylindrica	Pyrénées-Atlantiques	Grotte de Sare	mean	6	3.560	1.338	2.273	1.382	2.662
C. subcylindrica	Pyrénées-Atlantiques	Grotte de Sare	s.d.	6	0.119	0.037	0.382	0.088	0.062
C. subcylindrica	Pyrénées-Atlantiques	Grotte de Sare	min.	6	3.465	1.295	2.013	1.315	2.565
C. subcylindrica	Pyrénées-Atlantiques	Grotte de Sare	max.	6	3.762	1.400	3.030	1.554	2.747
C. vascanica	Prov. Asturias	Desfiladero de las Beyos	mean	7	4.386	1.708	2.660	1.670	2.568
C. vascanica	Prov. Asturias	Desfiladero de las Beyas	s.d.	7	0.212	0.023	0.091	0.034	0.102
C. vasconica	Prov. Asturias	Desfiladero de los Beyas	min.	7	4.205	1.670	2.538	1.616	2.482
C. vascanica	Prov. Asturias	Desfiladero de los Beyos	max.	7	4.708	1.736	2.764	1.704	2.715
C. vascanica	Prov. Cantabria	NW. of Otañes		1	2.982	1.194	1.783	1.167	2.497
C. vasconica	Prov. Cantabria	NW. of Otañes		1	2.950	1.125	1.744	1.165	2.622
C. vasconica	Prov. Cantabria	NW. of Otañes		1	3.018	1.254	1.802	1.172	2.407
C. vasconica	Prov. Cantabria	SE. of Llaguno		1	2.986	1.223	1.729	1.151	2.442
C. vasconica	Prov. Cantabria	SE. of Llaguno		1	3.114	1.277	1.973	1.182	2.439
C. vasconica	Prov. Cantabria	SE. of Llaguno		1	3.064	1.260	1.963	1.341	2.432
C. vasconica	Prov. Cantabria	3 km S. of Orduña		1	3.322	1.323	1.935	1.268	2.511
C. vasconica	Prov. Cantabria	3 km S. of Orduña		1	3.325	1.302	1.970	1.322	2.554
C. vascanica	Prov. Guipúzcoa	NE. of Aragotz		1	2.905	1.178	1.652	1.127	2.466
C. vasconica	Prov. Guipúzcoa	NE. of Aragotz		1	3.020	1.224	1.779	1.174	2.467
C. vascanica	Prov. Guipúzcoa	NE. of Aragotz		1	2.916	1.194	1.816	1.207	2.442
C. vasconica	Prov. Navarra	E. of Puerto de Usategueta		1	4.170	1.467	2.425	1.596	2.843
C. vasconica	Prov. Vizcaya	near Dima		1	2.918	1.205	1.885	1.243	2.422
C. vasconica	Prov. Vizcaya	near Dima		1	2.994	1.156	1.768	1.179	2.590
C. vasconica	Prov. Vizcaya	W. of Ranera	mean	17	3.251	1.309	1.943	1.298	2.485
C. vasconica	Prov. Vizcaya	W. of Ranero	s.d.	17	0.154	0.045	0.069	0.047	0.085
C. vasconica	Prov. Vizcaya	W. of Ranero	min.	17	3.072	1.226	1.834	1.221	2.357
C. vasconica	Prov. Vizcaya	W. of Ranero	max.	17	3.616	1.404	2.053	1.414	2.699

Table II. Summary of measurements (mm) of shells of *Cryptazeca* species and comparisons with data from literature. N = number of intact adult shells measured; SH = shell height; SB = shell breadth; measurements (mm) from literature are cited in the form in which they were published; measurements of the lectotype of *C. subcylindrica* are based on GITTENBERGER (1983: fig. 12).
Tabla II. Resumen de las medidas (mm) de las conchas de las especies de Cryptazeca *y comparación con los datos de la literatura. N = número de conchas adultas intactas medidas; SH = altura de la concha; SB = anchura de la concha; las medidas (mm) de procedentes de la bibliografía son citadas en la forma en que fueron publicadas; las medidas del lectotipo de* C. subcylindrica *se basan en GITTENBERGER (1983: fig. 12).*

Species	Source	N	SH range	SB range	SH/SB range	SH/SB mean ± s.d.
C. monodonta	Gittenberger, 1983	24?	3.15-3.8	1.55-1.7		
	Gómez, 1990b	?				2.23 ± 0.06
	this study	72	3.20-3.94	1.47-1.73	2.05-2.33	
C. kobelti	Gittenberger, 1983	4	3.5-3.7	1.65-1.7		
	Gómez, 1990b	?				2.16 ± 0.06
	this study	28	3.33-4.01	1.59-1.83	2.07-2.28	
C. subcylindrica	Gittenberger, 1983	20	3.5-4.55	1.25-1.5		
	ditto, lectotype	1	4.3	1.4	3.08	
	this study	6	3.47-3.76	1.30-1.40	2.57-2.75	
C. vasconica	Gittenberger, 1983	6	2.9-4.3	1.2-1.7		
	Gómez, 1990b	?				2.46 ± 0.11
	this study	48	2.91-4.71	1.13-1.74	2.36-2.84	
C. spelaea	Gómez, 1990a	16	7.25-8.15	2.60-2.90		
	Gómez, 1990b	16?				2.67 ± 0.11
C. elongata	Gómez, 1990b	4	6.20-7.00	2-2.35		2.93 ± 0.15

Cryptazeca kobelti Gittenberger, 1983, *Zool. Meded.*, 57 (23): 313 [Type locality: Conca d'Orduña, Spain].

C. kobelti was described from just four old shells from Conca de Orduña in Prov. Navarra (GITTENBERGER, 1983) [the actual localities were probably in an area that is now within Prov. Alava] and compared with *ca* 24 old shells of *C. monodonta*. The present study used 72 shells of *C. monodonta* (from 2 localities) and 28 of *C. kobelti* (from 4 localities in 2 areas). Based on the larger samples now available it is clear that these taxa overlap widely in shell size and form (Tables I, II; Fig. 2). The key by GÓMEZ (1990b) gave shell height/shell breadth as 2.2-2.35 in *C. monodonta* and 2.1-2.2 in *C. kobelti*, whereas our measurements give ratios respectively of 2.05-2.33 and 2.07-2.28 so that most individual shells are inseparable on this basis. In the original description of *C. kobelti*, GITTENBERGER (1983: 313) described *C. monodonta* as "more spindle-shaped and less pale in colouration (judging after only one fresh specimen of *C. kobelti* and several of *C. monodonta*)". However, in our material the shapes of individual shells of the two taxa can be closely matched (cf. Fig. 2). There is also no difference whatever in the brown coloration of shells of the two taxa when modern specimens collected alive are compared. Gittenberger's "fresh" shells must anyway have been about 90 years old when he studied them.

Locality data reported by ALTONAGA *ET AL.* (1994) for *C. kobelti* included sites in the Spanish Provinces of Guipúzcoa and Vizcaya situated between the type-locality near Orduña and the localities for *C. monodonta* in Dept. Pyrénées-Atlantiques

(Fig. 3A). Our few specimens from near Madariaga (Prov. Guipúzcoa) could only be identified arbitrarily as either *C. kobelti* or *C. monodonta*. Hence, it seems clear that *C. kobelti* should be regarded as a synonym of *C. monodonta*. The species lives amongst leaf-litter in moist deciduous woodland, including hillside *Fagus sylvatica* woods near Orduña (elevation *ca* 540-570 m) and near Madariaga (at elevations of 656 and 675 m), and more varied woodland with *Quercus*, *Acer*, *Fraxinus excelsior*, *Corylus avellana* and other trees and shrubs at Grotte de Sare (elevation *ca* 220 m). Most if not all the localities overlie limestone bedrock and there is much exposed rock at some of them, whereas several others lack rock exposures in the places where the species was collected alive.

Cryptazeca subcylindrica De Folin & Bérillon, 1877

Cryptazeca monodonta var. *subcylindrica* De Folin & Bérillon, 1877, *Bull. Soc. Borda Dax*, 2 (4): 443, pl. 3, fig. 6 [Type locality: "Bramepan", St. Pierre-d'Irube SE. of Bayonne, Pyrénées-Atlantiques, France]. See Gittenberger & Kosten (1983) for bibliographical details.

Ferussacia (*Hypnophila*?) *vasconica* Kobelt, 1894, *Icon. Land- & Süsswass.-Moll.*, (N.F.) 7 (1-4): 37, pl. 188, fig. 1200 [Type locality: Orduña, Prov. Alava, Spain].

Recent collections of *C. vasconica* show a wide range of variability in shell size and shape (Figs. 2A-F, Table I). In different populations the shell height ranges from 2.9-3.0 mm (N. of Araotz, Prov. Guipúzcoa) to a mean of 4.4 mm (Desfiladero de los Beyos, Prov. Asturias) and shell shape ranges from subcylindrical to narrowly conical or narrowly fusiform (Fig. 2). Shell colour is typically light brown (lighter than in *C. monodonta*), but colourless shells occur inside caves (Gómez, 1990b: 373; Altonaga *et al.*, 1994: 76). Measurements of our material of *C. subcylindrica* from near the Grotte de Sare (Dept. Pyrénées-Atlantiques) are within the overall range of shell size and shape found in *C. vasconica* (Table I, Fig. 2). The freshest empty shells (at least one collected alive) from Grotte de Sare include two that are pale brown and one that is almost colourless (part of NMW.Z. 1993.052.10530). As pointed out by Gittenberger (1983) and Gómez (1990b: 373), the transverse sculpture in *C. subcylindrica* is strong; on the freshest shells it is closely similar to that of *C. vasconica*. A single adult specimen from our easternmost Spanish locality for *C. vasconica* near the Puerto de Usateguieta (Prov. Navarra) is so close to the *C. subcylindrica* from Grotte de Sare in shell size and form (cf. Figs. 2F and 2G) that identifying them as separate species seems arbitrary.

The lectotype of *C. subcylindrica* figured by Gittenberger (1983: 314) is a very narrow shell (shell height/shell breadth 3.08), whereas the measurements he gives for other specimens widely overlap those of our material from Grotte de Sare. Although he reported the shell of that species as colourless, this is not true of some from Grotte de Sare, whereas some *C. vasconica* are colourless, as noted above. Hence most *C. subcylindrica* (including our material from Grotte de Sare) show shells that are within the range of variation found in different populations of *C. vasconica*, only the lectotype being notably narrow (although the *C. vasconica* shell from Puerto de Usateguieta approaches this with shell height/shell breadth of 2.84). It therefore seems better to regard these taxa as conspecific, with *C. vasconica* treated as a synonym of *C. subcylindrica* which has the older name. The alternative of dividing *C. vasconica* into several closely split species might eventually prove to be justifiable, but there are too many intermediate populations for this to be warranted on the basis of the shell data alone. Although anatomical and molecular comparisons are desirable, we have failed to obtain living *C. subcylindrica* on recent visits to sites near its French type locality.

C. subcylindrica sensu lato is an elusive snail that is usually found in small numbers in more or less shaded places

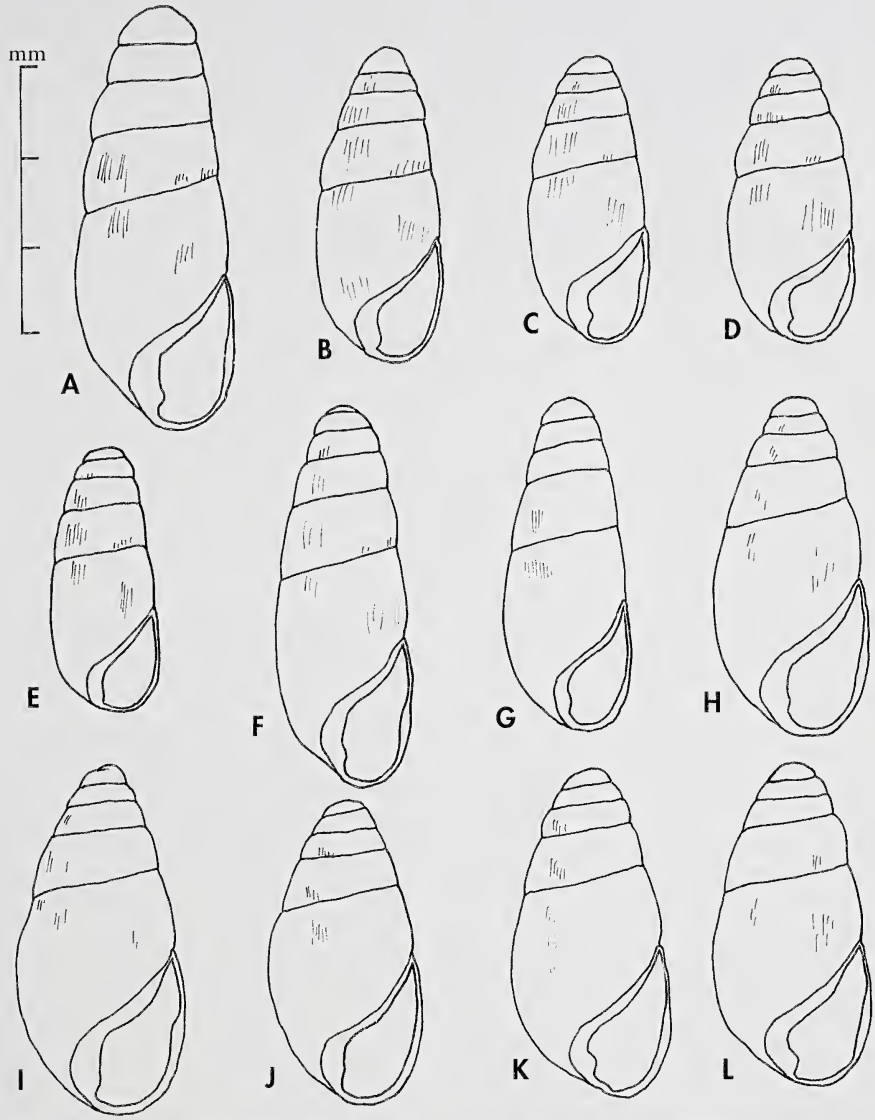

Figure 2. Drawings of representative shells of *Cryptazeca* species. A: *C. vasconica*, by San Ignacio turning, Prov. Asturias; B-D: *C. vasconica*, W. of Ranero, Prov. Vizcaya; E: *C. vasconica*, NE. of Araotz, Prov. Guipúzcoa; F: *C. vasconica*, Puerto de Usateguieta, Prov. Navarra; G: *C. subcylindrica*, Grotte de Sare, Pyrénées-Atlantiques; H: *C. monodonta*, Grotte de Sare, Pyrénées-Atlantiques; I: *C. kobelti*, 3 km along road S. of Orduña, Prov. Alava; J: *C. kobelti*, 4 km along road S. of Orduña, Prov. Alava; K: *C. kobelti*, site E149, E. of Madariaga, Prov. Guipúzcoa; L: *C. monodonta*, Grotte de Sare, Pyrénées-Atlantiques; all specimens are in the Collection of G.A. and D.T. Holyoak.

Figura 2. Dibujos de varias conchas representativas de las especies de Cryptazeca. *A:* C. vasconica, *de San Ignacio turning, Prov Asturias; B-D:* C. vasconica, *W. de Ranero, Prov. Vizcaya; E:* C. vasconica *NE. de Araotz, Prov. Guipúzcoa; F:* C. vasconica, *Puerto de Usateguieta, Prov. Navarra; G:* C. subcylindrica, *Grotte de Sare, Pyrénées-Atlantiques; H:* C. monodonta, *Grotte de Sare, Pyrénées-Atlantiques; I:* C. kobelti, *3 km por la carretera al S. de Orduña, Prov. Alava; J:* C. kobelti, *4 km por la carretera al S. de Orduña, Prov. Alava; K:* C. kobelti, *lugar E149, E. de Madariaga, Prov. Guipúzcoa; L:* C. monodonta, *Grotte de Sare, Pyrénées-Atlantiques; todos los ejemplares están en la Colección de G.A. y D.T. Holyoak.*

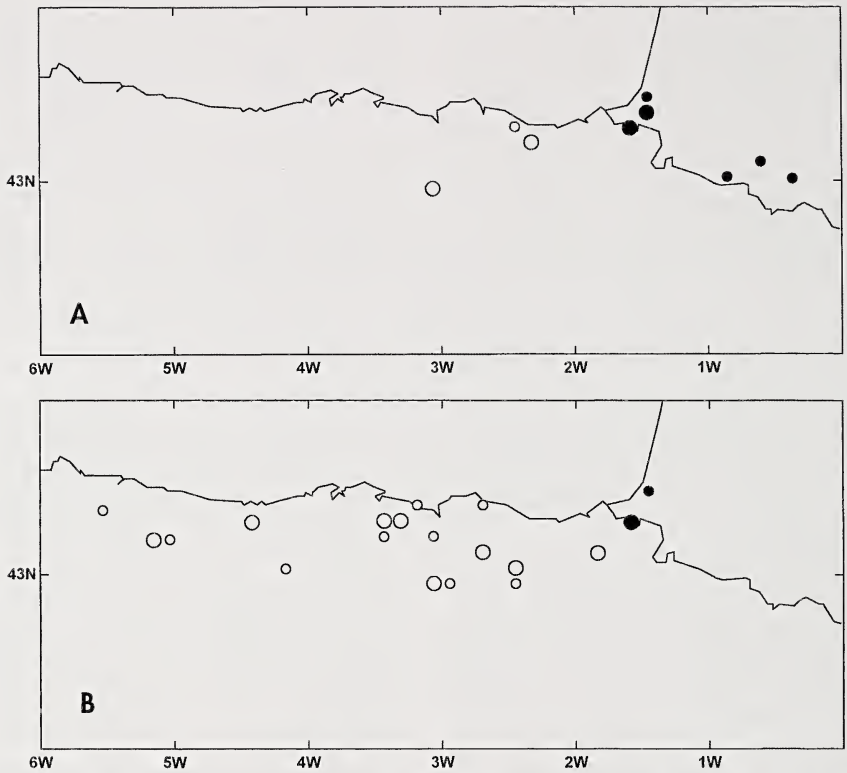

Figure 3. Distribution of some *Cryptazeca* species mapped in 10 km squares of the U.T.M. grid. A: *C. monodonta sensu lato*, closed symbols= records originally determined as *C. monodonta*, open symbols= records originally determined as *C. kobelti*, large symbols= authors' records, small symbols= records from literature; B: *C. subcylindrica sensu lato*, closed symbols= records originally determined as *C. subcylindrica*, open symbols= records originally determined as *C. vasconica*, large symbols= authors' records, small symbols= records from literature. The report of *C. monodonta* from Prov. Asturias by BECH (1986) is not mapped because the species identification seems unlikely (the shell height was given as 3.15 mm, shell breadth [erroneously?] as 3.8 mm).

Figura 3. Distribución de varias especies de Cryptazeca *en cuadrículas UTMs. de 10 km de lado. A:* C. monodonta sensu lato, *círculos negros= citas determinadas originalmente como* C. monodonta, *círculos blancos= citas determinadas originalmente como* C. kobelti, *símbolos grandes= citas de los autores, símbolos pequeños= citas procedentes de la literatura; B:* C. subcylindrica sensu lato, *círculos negros= citas determinadas originalmente como* C. subcylindrica, *círculos blancos= citas determinadas originalmente como* C. vasconica, *símbolos grandes= citas de los autores, símbolos pequeños= citas procedentes de la literatura. La cita de* C. monodonta *de la Prov. Asturias de* BECH *(1986) no ha sido representada en el mapa ya que la identificación de la especie es dudosa (la altura de la concha indicada es de 3,15 mm, su anchura [¿errónea?] es de 3,8 mm).*

that have exposed limestone rocks, sometimes under closed cover of deciduous woodland, sometimes on more open crags or limestone pavement with only scattered trees and shrubs. Litres of sievings from ground litter commonly held only a few shells and repeated visits to the same locality were often unsuccessful in finding more. Our only locality that produced a large sample (32 snails or shells, 12 of them living) was at the damp bottom of a solution hollow in limestone pavement, 5 m below the ground surface, where permanently shaded by the

surrounding rocks and by trees (W. of Ranero, Prov. Vizcaya). The species is also reported from inside caves (see above). Overall, this species appears much more closely restricted to sheltered and shaded rock crevices than *C. monodonta*, with no confirmed occurrences in woodland leaf-litter at sites lacking exposed rocks.

DISCUSSION

Revised key to *Cryptazeca* species

Reduction of the number of species recognised within *Cryptazeca* greatly simplifies identification of its species. The key to adult shells presented by GÓMEZ (1990b: 373) can be revised as follows:

1 - Shell height > 5.5 mm (cave species) 2
- Shell height < 5.5 mm (in open habitats or caves) 3

2 - Shell height/shell breadth > 2.8 . . . . . *C. elongata*
- Shell height/shell breadth < 2.8 . . . . . *C. spelaea*

3 - Shell height/shell breadth > 2.35, shell with strong transverse sculpture . . . . . *C. subcylindrica*
- Shell height/shell breadth < 2.35, shell with transverse sculpture weak or nil . . . . . *C. monodonta*

Conservation status of the enlarged *C. monodonta* and *C. subcylindrica*

Three of the four taxa of *Cryptazeca* discussed above are included in the IUCN Red List (Mollusc Specialist Group, 1996): *C. kobelti* as Endangered (under criteria B1 + 2c), *C. monodonta* and *C. subcylindrica* both as Vulnerable (under criterion D2), whereas *C. vasconica* is regarded as Lower Risk/near threatened. Two of the taxa are now protected by law in France, as Mollusque protégés, *C. monodonta* under Article 4, *C. subcylindrica* as a Rare species under Article 1. Our proposal to regard *C. kobelti* as conspecific with *C. monodonta* adds three French localities with modern records to those in Spain, thus increasing the species' range and presumably reducing its global threat status to Vulnerable. Nevertheless, it remains a localised endemic occurring only in sites that are species-rich for land-snails and which need to be protected (see Appendix). The proposal to regard *C. vasconica* as conspecific with *C. subcylindrica* will greatly increase the species' range and number of localities with modern records, presumably implying that the overall threat status should be Lower Risk/near threatened (i.e. no longer on the Red List).

ACKNOWLEDGEMENTS

Thanks are due to the Dept. of BioSYB at National Museum and Gallery of Wales, Cardiff, U.K. (NMW.Z) for loans of specimens and Jennifer Gallichan and Dr Graham Oliver for helping with arrangements for the loan. Thanks are also due to Jonathan Ablett for assistance in studies at the Natural History Museum, London, U.K. Figure 3 was prepared using the DMAP software written by Dr A.J. Morton.

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APPENDIX. MATERIAL STUDIED.

Data are listed in sequence as province, locality name, habitat description, associated species, altitude, U.T.M. grid reference, date, collectors' initials, collector's field number, number of shells or specimens (immature or adult, whether alive or dead when collected), collection, registration number if any. Abbreviations: CGAH = Collection of G.A. & D.T. Holyoak, DTH = D.T. Holyoak, GAH = G.A. Holyoak, MH = M. Holyoak, MBS = M.B. Seddon, NHMUK = Natural History Museum, London, U.K.; NMW.Z. = Department of BioSYB, National Museum and Gallery of Wales, Cardiff, U.K.; sh = shells, sp = spirit specimens.

C. kobelti SPAIN, Prov. Alava: by N625 *ca* 3 km S. of Orduña, steep limestone hillside with *Fagus* woodland, damp beneath, with few saplings & bushes, "*ca* 610 m alt.", VN3, 26 Aug. 1984, DTH, MH, MBS, 43 sh (adults & immatures, alive & dead), NMW.Z.1993.052.10453; by A625 *ca* 3 km S. along road from Orduña, from leaf-litter on N.-facing slope in beechwood, *ca* 540 m alt., 30T 049797/47574, 9 June 2007, GAH, DTH, site 33, 6 sh (adults, alive), CGAH; by A625 *ca* 4 km S. along road from Orduña, from leaf-litter on N.-facing slopes in beechwood, *ca* 570 m alt., 30T 04977/47557, 9 June 2007, GAH, DTH, site 34, 5 sh (2 immatures & 3 adults, alive & dead), CGAH; Prov. Guipúzcoa: E. of Madariaga (NW. of Azkoitia), N.-facing slope with few limestone crags, under mature beech wood, 656 m alt., 30T 05560/47840, 8 May 2011, GAH, DTH, site E148, 1 sh (adult, alive), CGAH; E. of Madariaga (NW. of Azkoitia), N.-facing slope with few limestone crags & beech wood, 675 m alt., 30T 05551/47842, 9 May 2011, GAH, DTH, site E149, 6 sh (1 adult & 5 immatures, alive & dead), CGAH.

C. monodonta FRANCE, Dept. Pyrénées-Atlantiques: "Basses-Pyrénées", Ex. A.M. Norman Coll. (Ex Morelet), 3 sh, NHMUK.1958.9.3.1-3; 1 km SW. of Ustaritz (*ca* 8 km NW. of Cambo), mixed deciduous wood with *Corylus* understorey in valley of small stream, 24 Aug. 1980, DTH, 23 sh (alive & dead), NMW.Z.1993.052.04432; near Grotte de Sare, 5.5 km S. of Sare, mixed deciduous wood on rocky limestone slope, moss-rich ground vegetation, 23 Aug. 1980, DTH, 29 sh (alive & dead), NMW.Z.1993.052.04408; Grotte de Sare, rocky limestone slope, shaded by mixed deciduous trees, very mossy with dead wood lying, *ca* 300 m alt., XN1, 6 Aug. 1983, DTH, MBS, 6 sh, NMW.Z.1993.052.07652; Grotte de Sare, rocky limestone slopes shaded by mixed deciduous wood, moist & mossy, XN1, 28 Aug. 1984, DTH, MH, MBS, 56 sh (dead), NMW.Z. 1993.052.10528; near Grotte de Sare, limestone slopes near stream in deciduous woods, *ca* 200 m alt., 43°16′ N., 1°34′W., 19 May 2001, GAH, 4 sh (adults, alive & dead), CGAH; Grotte de Sare, rocky limestone slope with deciduous woodland cover, 220 m alt., 30T 061587/479160, 7 May 2011, GAH, DTH, site F146, 1 sp & 11 sh (6 adults [1 damaged] & 6 immatures, 1 alive & 10 dead), CGAH.

C. subcylindrica FRANCE: Dept. Pyrénées-Atlantiques: near Grotte de Sare, 5.5 km S. of Sare, mixed deciduous wood on rocky limestone slope, moss-rich ground vegetation, with *Cryptazeca monodonta*, 23 Aug. 1980, DTH, 3 sh (2 immatures & 1 adult, dead), NMW.Z.1993.052.04420; Grotte de Sare, rocky limestone slope, shaded by mixed deciduous trees, very mossy with dead wood lying, *ca* 300 m alt., XN1, 6 Aug. 1983, DTH, MBS, 1 sh (immature, dead), NMW.Z.1993.052.07653; Grotte de Sare, rocky limestone slopes shaded by mixed deciduous wood, moist & mossy, XN1, 28 Aug. 1984, DTH, MH, MBS, 5 sh (1 immature & 4 adults, alive & dead), NMW.Z.1993.052.10530; Grotte de Sare, rocky limestone slope with deciduous woodland cover, 220 m alt., 30T 061587/479160, 7 May 2011, GAH, DTH, site F146, 2 sh (1 adult & 1 immature, dead), CGAH.

C. vasconica SPAIN, Prov. Alava: by N625 *ca* 3 km S. of Orduña, steep limestone hillside with *Fagus* woodland, damp beneath, with few saplings & bushes, *ca* 610 m alt., VN3, 26 Aug. 1984, DTH, MH, MBS, 3 sh (dead), NMW.Z.1993.052.10455; Prov. Asturias: near AS261, by San Ignacio, limestone scree on wooded slope by stream bank, *ca* 270 m alt., [approximately] 30T 03302/47871, 24 June 2007, GAH, site 46, (5 adults & 5 immatures, dead), CGAH; near N625 in N. part of Desfiladero de los Beyos (by turn to San Ignacio), base of limestone crag with ledges, scree & ephemeral waterfall, shaded by low deciduous woodland, 184 m alt., 30T 032997/478728, 13 May 2011, GAH, DTH, site E159b, 3 sh (2 adults [1 broken] & 1 immature, dead), CGAH; Prov. Cantabria: just SE. of Llaguno (SW. of Castro-Urdiales), limestone road-cutting, crag & deciduous woodland on slope, 252 m alt., 30T 04786/47940, 10 May 2011, GAH, DTH, site E153, 8 sh (2 adults & 6 immatures, 3 alive & 5 dead), CGAH; S. of CA250 just NW. of Otañes, base of limestone crag with few oak trees, block-scree locally, 136 m alt., 30T 04830/47985, 10 May 2011, GAH, DTH, site E152, 5 sh (3 adults & 2 immatures, dead but 1 shell fresh), CGAH; Prov. Guipúzcoa: by GI3592 NE. of Araotz, rocky limestone slopes & crags, above river, with patchy scrub & low woodland, 398 m alt., 30T 05459/47610, 9 May 2011, GAH, DTH, site E150, 3 sh (adults, alive), CGAH; Prov. Navarra: by NA4150 *ca* 2 km E. of Puerto de Usateguieta, rocky limestone slopes with deciduous woodland (mainly beech), 644 m alt., 30T 059231/477150, 8 May 2011, GAH, DTH, site E147, 2 sh (1 adult & 1 immature, alive & dead), CGAH; Prov. Vizcaya: W. of Ranero (E. of Ramales de la Victoria), from litter at base of deep shaded hollows on limestone slope, *ca* 500 m alt., 30T 04692/47902, 14 & 15 June 2007, GAH, DTH, site 40, 3 sp & 29 sh (18 adults [1 broken] & 14 immatures, 12 alive & 20 dead), CGAH; by BI2543 near Dima, rocky limestone slope with crags and patches of Hazel coppice, 247 m alt., 30T 05209/47746, 9 May 2011, GAH, DTH, site E151, 4 sh (2 adults & 2 immatures, 1 alive & 3 dead), CGAH.

Reproduction in two sympatric Iberian nudibranch species (Gastropoda: Opisthobranchia) with contrasting development types

Reproducción en dos especies simpátricas de nudibranquios (Gastropoda: Opisthobranchia) de la Península Ibérica con tipos de desarrollo alternativos

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ABSTRACT

Doriopsilla areolata and *D. pelseneeri* are two sympatric species from the Iberian Peninsula that contrast in their reproductive modes. In this study we investigated the developmental mode of both species, comparing egg number and egg volume. In addition, we investigate whether the type of development influences the amount of energy allocated for reproduction.

Animal weight was found to be positively correlated with egg number per egg mass but not with egg volume, which seems to be a specific character in both species. Moreover, our results suggest that both species allocate the same amount of energy for reproduction, in terms of body weight, though a clear difference in the way these resources are used was actually observed. *Doriopsilla areolata* invested 2.22 ± 1.87% of body weight (n=36) essentially for egg production, whereas *D. pelseneeri* invested 5.72 ± 3.31% of body weight (n=11) on rich gel matrix spawn masses. The different type of development could provide an explanation for the difference in the geographical range of both species, but further studies are required.

RESUMEN

Doriopsilla areolata y *D. pelseneeri* son dos especies simpátricas en la Península Ibérica, que contrastan en sus modos de reproducción. En este trabajo se investigó el modo de desarrollo de ambas especies, comparando el número y el volumen de huevos. Además, se investiga si el tipo de desarrollo influye en la cantidad de energía dedicada a la reproducción.

El peso del animal muestra una correlación positiva con el número de huevos por masa de huevos, pero no con el volumen del huevo, que parece ser un carácter específico en ambas especies. Nuestros resultados sugieren que ambas especies asignan, en términos de peso corporal, la misma cantidad de energía para la reproducción, pero la forma en que estos recursos se utilizan es diferente. *Doriopsilla areolata*, invirtió 2,22 ± 1,87% de su peso corporal (n = 36), esencialmente para la producción de huevos, mientras que *D. pelseneeri* ha invertido 5,72 ± 3,31% de su peso corporal (n = 11) en la matriz de gel enriquecido de las masas. El tipo de desarrollo podría explicar la diferencia en la distribución geográfica de las dos especies, pero se necesitan más estudios.

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INTRODUCTION

As far as their reproduction is concerned, opisthobranchs display a diversity of strategies (Rudman and Willan, 1998). Several works report on species displaying different larval development types: planktotrophy, lecithotrophy, and direct development (Hadfield and Switzer-Dunlap, 1984; Hadfield and Miller, 1987; Bouchet, 1989; Todd, 1983). However, the selective factors in determining these larval strategies remain to be ascertained. According to Hadfield and Miller (1987), for any of those three "different means to the same end" the time required to reach the juvenile stage is variable; usually, the larger the egg, the longer the pre-hatching period.

Doriopsilla areolata (Bergh, 1880) and *Doriopsilla pelseneeri* (d'Oliveira, 1895) are two radula-less, porostomate nudibranchs belonging to the family Dendrodorididae. They are amongst the most common nudibranchs inhabiting the Iberian coasts. Although sympatric and occasionally feeding upon the same sponges (GC, personal observations), both species have rather different types of development. *Doriopsilla areolata* has a planktotrophic development type, producing egg masses that are formed by numerous small eggs, while *D. pelseneeri* displays a metamorphic, direct development type and produces a lower number of larger eggs (Soares and Calado, 2006).

The known geographical range is also different. *Doriopsilla areolata* is known to occur between the North coast of Spain and the Cape Verde Islands (including the Mediterranean Sea), Ghana and Angola, whereas *D. pelseneeri* is restricted to the Atlantic and Mediterranean coasts of the Iberian Peninsula. The aim of this study is to compare the developmental mode of both species, comparing egg number and egg volume. Further, we intend to test whether the type of development influences the amount of energy allocated for reproduction.

MATERIALS AND METHODS

Animals of both species were collected from two localities along the Arrabida coast (West Portuguese Coast) and Ria de Ferrol (Galicia, NW Spain). The exact localities can be found in Soares and Calado (2006). All specimens were collected by hand while scuba diving at 5-15 m depth from March to July of 2003, in the period reported as the peak of their reproduction period.

Animals were maintained under laboratory conditions as described elsewhere (Soares and Calado, 2006). Specimens were paired periodically for copulation and after approximately one week, egg masses were laid and removed immediately. In order to estimate the number of eggs, spawn masses were measured (top, base length, and width). We collected a total number of 61 *Doriopsilla areolata* and 39 *D. pelseneeri*, from which we studied 43 and 21 laid egg masses, respectively. Each set animal-spawn mass was weighed in fresh for later use in calculations.

As for *Doriopsilla areolata*, three 1mm wide transverse sections of the egg masses were cut for observation under a stereomicroscope. Spawns from *D. pelseneeri* were observed intact under a stereomicroscope. Immediately after oviposition, and before any cleavage was observed, eggs were counted in a known egg mass area and its larger diameter measured to estimate egg number per egg mass and egg volume, respectively.

In order to establish a calibration curve fresh weight/dry weight, three *Doriopsilla pelseneeri* specimens and four *D. areolata* specimens were weighed without water excess and dried at 60°C to constant weight (Smith and Sebens, 1983). Afterwards, a fraction of all dried samples were used to calculate ash values by ignition (3 hours at 550°C in a muffle furnace), by the estimation of ash-free dry weight equivalents (Havenhand and Todd, 1988; Todd, 1979). The same procedure was used on five egg masses of each species, as well

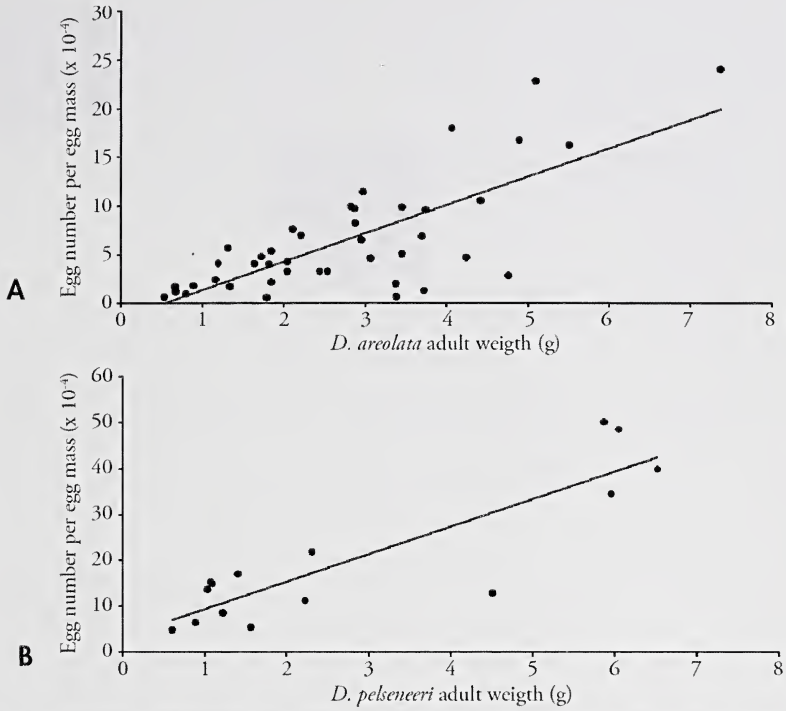

Figure 1. Relationship between egg number per egg mass and adult animal weight for (A) *D. areolata* (R2= 0.563) and (B) *D. pelseneeri* (R2= 0.768).
Figura 1. Relación entre el número de huevos por masa de huevo y peso del animal adulto en (A) D. areolata *(R2= 0,563) y (B)* D. pelseneeri *(R2= 0,768).*

as in two spawn masses of *D. pelseneeri*, from which eggs were previously removed manually. For *D. areolata* it was assumed that egg masses were entirely composed of eggs, since it was impossible to detach eggs from the feeble gel matrix. A measure of the reproductive effort per egg mass was calculated as the ratio between the dry weight of a single egg mass and the dry weight of the progenitor adult inferred from the fresh weight by the calibration curve. Finally, how much energy (inferred by the amount of biomass) is allocated per egg mass and per egg unit, was calculated.

Statistical analyses were conducted using STATISTICA (Release 6.0). Regression analysis was performed to investigate the relationship between both egg number and egg volume (mean values) and adult body weight. Differences between egg masses of the distinct populations (Portugal and Spain) were also investigated.

RESULTS

Egg number per egg mass and egg volume

As presented in SOARES AND CALADO (2006), the egg number per egg mass in *D. areolata* was estimated to be between 5,500 – 240,000 eggs (n=43), whereas in *D. pelseneeri* egg number varied from 300 to 5,000 (n=15) eggs per egg mass.

In both species it is clear that egg number in a single spawn mass is positively correlated with animal weight (R2= 0.563 for *Doriopsilla areolata* and R2= 0.768 for *D. pelseneeri*) as can be seen in Figure 1. The geographical area

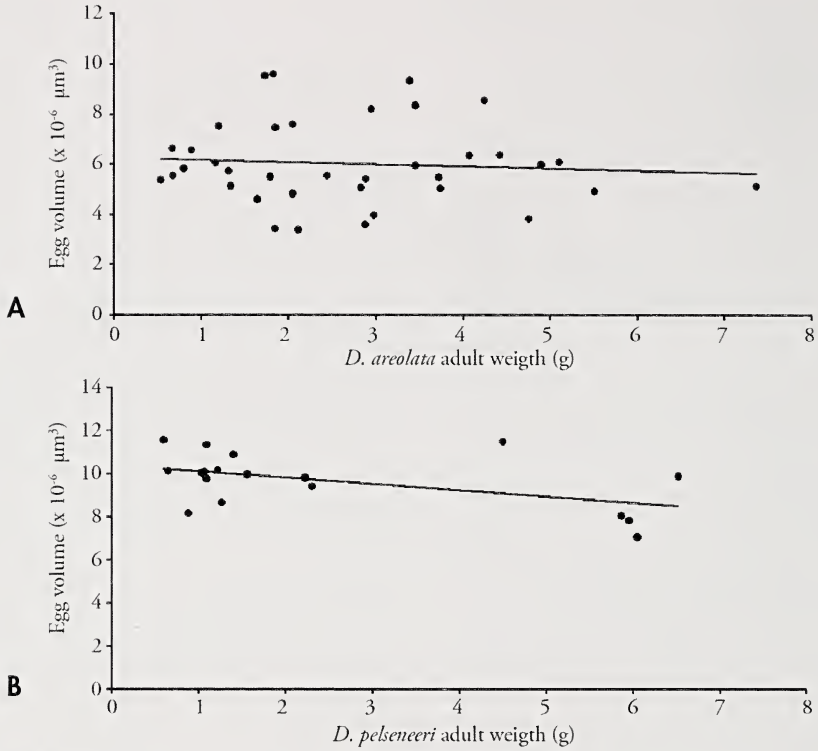

Figure 2. Relationship between egg volume and adult animal weight for (A) *D. areolata* (R2= 0.006) and (B) *D. pelseneeri* (R2= 0.240).
Figura 2. Relación entre el volumen del huevo y peso del animal adulto en (A) D. areolata *(R2= 0,006) y (B)* D. pelseneeri *(R2= 0,240).*

from where animals were collected seems to have no influence on this analysis. However, specimens from Galicia were observed to be slightly smaller and therefore to deposit smaller egg masses than those collected in Portugal.

Moreover, it was observed that egg volume does not appear to co-vary with animal weight (R2= 0.006 for *Doriopsilla areolata* and R2= 0.240 for *D. pelseneeri*) as illustrated in Figure 2. Indeed, egg volume seems to be a specific character in both species.

Reproductive investment in the two species

Dry weight analysis revealed that *Doriopsilla pelseneeri*'s body contains on average 87.94 ± 2.22% (n=3) of water, whereas *D. areolata* contains 84.20 ± 2.41% (n=4), which reveals a similar hydrate condition in both species. From the ash content analysis it was estimated that *D. pelseneeri* contains 4.30 ± 1.42% (n=3) of inorganic matter in the body, whereas *D. areolata* contains 7.95 ± 1.34% (n=4) (mean values).

Doriopsilla pelseneeri egg masses contained 90.57 ± 3.03% (n=5) of water and 4.13 ± 0.89% (n=5) of inorganic matter, whereas *D. areolata* egg masses contained 92.73 ± 2.08% (n=5) of water and 4.55 ± 0.85% (n=2) of inorganic matter (mean values). In the former species egg masses are made of 39% of eggs and 61% of gel matrix, which contains 88.53 ± 1.66% (n=2) of water and 6.90 ± 1.08% (n=2) of inorganic matter. Since for *D. areolata* it has been impossible to detach

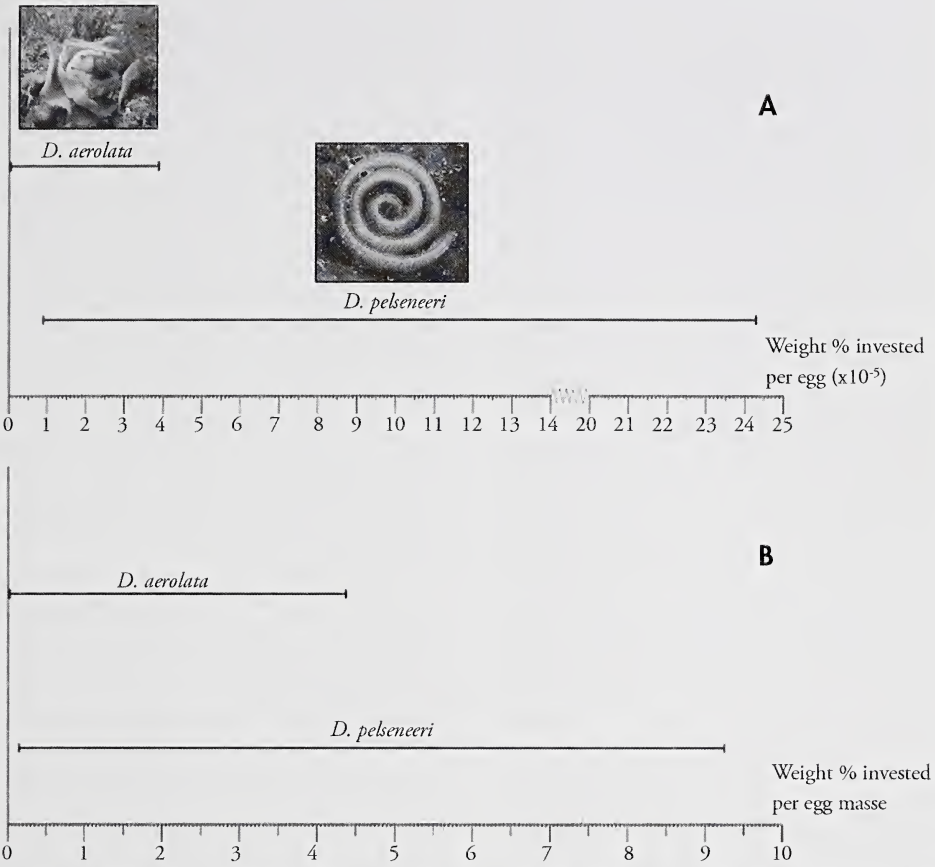

Figure 3. Relationship between weight invested (A) per egg mass and (B) per egg (%) for *D. areolata* and *D. pelseneeri*.

Figura 3. Relación entre el peso invertido (A) por unidad de masa de huevos y (B) por huevo (%) para D. areolata *y* D. pelseneeri.

eggs from the jelly matrix, egg masses were assumed to be made up nearly 100% of eggs.

With these values we obtain that *D. pelseneeri* invested 0.0012 ± 0.0009% of their weight per single egg (n=11, mean value of the range 0.00009% - 0.00243%), while *D. areolata* invested 0.00026 ± 0.00009% of their body weight per single egg (n=36, mean value of the range 0.0000032% - 0.00039%) (Figure 3A). The investment per egg mass was also calculated; *Doriopsilla pelseneeri* specimens studied invested 5.72 ± 3.31% of their body weight (n=11, mean value of the range 0.305% - 9.479%), whereas *D. areolata*, invested 2.22 ± 1.87% (n=36, mean value of the range 0.012% - 4.767%) (Fig. 3B).

DISCUSSION

Developmental patterns in opisthobranchs have been a subject of much interest in the last decades (e.g. HADFIELD AND SWITZER-DUNLAP, 1984; HADFIELD AND MILLER, 1987; TODD, 2001, KRUG, 2009). However, obtaining a final consensus has not been possible so far and some authors claim that there is no single answer to what determines the

developmental mode of any individual opisthobranch species (Hadfield and Miller, 1987). Although sympatric and feeding on the same food items, *Doriopsilla pelseneeri* and *D. areolata* exhibit different developmental patterns. Soares and Calado (2006) demonstrated that *D. areolata* with planktotrophic development takes approximately half the time till hatching than *D. pelseneeri* with direct development.

Even with rather opposite developmental modes both species allocate about the same amount of energy for reproduction, as inferred from differences in body weight. However, there is a clear difference in the way these resources are used. *Doriopsilla areolata* expends most resources producing spawns with a high number of small eggs, and a very scarce gel matrix. Larvae hatch just a few days after egg mass deposition, as is typical for obligatory planktotrophs, and thus not many nutritive reserves are needed. In opposition, *D. pelseneeri* produces a small number of large, yolky eggs and a dense gel matrix in which they are embedded. The matrix is used for mechanical and, most certainly, for chemical protection of the embryos developing inside the egg-capsule. Since we did not have access to the complete reproductive period, we were unable to calculate the total reproductive effort for these two species and therefore to compare it with others (e.g. Todd, 1979; DeFreese and Clark, 1983; Gibson and Chia, 1991).

Another conclusion arises from our results, larger adult specimens produce higher numbers of eggs per egg mass. This has been observed for both species studied herein. Allen, Krug and Marshall (2009) report for the sacoglossan *Elysia stylifera* that larval size is determined by the extra-capsular yolk, but not by egg size. Todd, Lambert and Davies (2001), based on previous studies with *Adalaria proxima* (Alder and Hancock, 1854) (Lambert, Todd and Thorpe, 2000) generalise that between-population variation in egg size is genetically determined. Such a pattern was not observed herein. Egg size appears to be species specific regardless of the geographic area, and hence of the population.

As Strathmann (1986) refers, "differences in size and body plan account for much of the variation in types of larval development". Recently and using opisthobranchs as a model, Goddard (2004) agrees with this point of view. This author argues that phylogenetic constraints on developmental mode can be severe. For instance, if a feeding structure is lost the possibility of it being regained is very remote, constraining the whole lineage to a non-feeding developmental mode. In gastropods, however, this process could have happened more easily since lecitotrophic larvae often retain structures used in the process of feeding (Strathmann, 1978).

Since planktotrophy is clearly the most frequently observed development mode, Hadfield and Miller (1987) assume that this is also the most primitive developmental strategy amongst opisthobranchs. They argue that the evolutionary direction will be towards lecithotrophic-planktonic development and from there to direct development, in which the opisthobranchs with ametamorphic development are the most evolved forms. According to Todd (2001), a larger egg should not be the trigger for this change and for Hadfield and Miller (1987) it is not clear if the selective pressures responsible for this have been the same in all opisthobranch species. Intense predation on early juveniles could have selected for increased size, leading to a direct development mode, but in another situation the opisthobranch can be the predator and may adapt its own life cycle to grow and reproduce before a short-living prey is exhausted (Todd and Doyle, 1981). The costs for this adaptation will be, in part, a reduction in opisthobranch size and fecundity, and production of larger, lecithotrophic eggs or directly developed offspring (pelagic larva could be dispensable if prey is not too patchy) will be favoured (Hadfield and Miller, 1987). According to Todd (1991) a consensus is lacking and probably

there are special cases for particular species.

Planktotrophic species have a high fecundity and great dispersal potential, whereas species with direct development have a reduced fecundity with a higher larval stage protection and usually hatch and settle in the same places where their progenitors live (SCHELTEMA, 1986). The data available on the two species herein studied support this idea. *Doriopsilla areolata*, with planktotrophic development, has a wide geographic range whereas *D. pelseneeri*, with direct development, has a much more restricted distribution, mostly limited to the Iberian Peninsula (see also VALDÉS AND ORTEA, 1997). Potential dispersion capability of a species is dependent on many physical and biological habitat conditions (SCHELTEMA, 1986), however, and since both species feed on a variety of sponges widespread in the Lusitanian province (GC, personal observations), no host constraint should be involved in their actual distribution.

Studying two sympatric dorid nudibranchs with different larval strategies, TODD (1979) claimed that planktotrophic species were "forced" into that developmental mode since an insufficient number of lecithotrophic eggs would be produced to maintain its population stability. This author also suggested that selection always favours the strategy which produces the larger offspring survivorship even if it is energetically inefficient. However, as seen above, other authors claim that energetic factors seems to be a lesser deterministic factor for the selection of developmental pattern.

As HADFIELD AND MILLER (1987) already pointed out, there is "no valid reason to assume that species currently found together evolved in sympatry or under the conditions in which they are now found". Furthermore, it is not certain that planktotrophy and lecithotrophy are different processes aiming at the same final results (TODD, 1991). We are convinced that further phylogeographic studies on the populations of *Doriopsilla areolata* and *Doriopsilla pelseneeri* will help to elucidate the origins of the speciation process and therefore the evolutionary relationships between these two species.

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Asian openbill stork *Anastomus oscitans* as a predator of the invasive alien gastropod *Pomacea canaliculata* in Thailand

La cigüeña asiática de pico abierto *Anastomus oscitans* como un depredador del caracol manzana *Pomacea canaliculata*, especie exótica invasora en Tailandia

Weerachon SAWANGPROH*,**,[1], Philip D. ROUND** and Pilai POONSWAD***

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ABSTRACT

The freshwater golden apple snail *Pomacea canaliculata*, native to South and Central America, and the West Indies, is now a major agricultural pest in Thailand paddy fields. There is anecdotal evidence that the Asian openbill *Anastomus oscitans* consumes these snails, but no reports on its predation efficiency. Our study showed that the number of storks visiting the fields correlated with a decrease in snail abundance (rs= 0.902, p= 0.0001). Storks are tactile predators and preferred adult snails. This is probably more profitable for the birds, but keeps the *P. canaliculata* population 'sustainable'.

RESUMEN

El caracol manzana dorado *Pomacea canaliculata*, una especie de agua dulce originaria de América del Sur y Central y del Caribe, es actualmente una plaga agrícola importante en los arrozales de Tailandia. Se sabe que las cigüeñas asiáticas de pico abierto *Anastomus oscitans* consumen estos caracoles, pero no hay datos sobre la eficacia de esta predación. En este trabajo se muestra que hay una correlación entre el número de cigüeñas que visitan los arrozales y una disminución en la abundancia de caracol (rs= 0,902, p= 0,0001). Las cigüeñas son depredadores táctiles y prefieren caracoles adultos. Esto es probablemente más rentable para las aves, pero mantiene la población de *P. canaliculata* en niveles "sostenibles".

INTRODUCTION

Golden apple snails *Pomacea canaliculata* (Lamarck, 1822) are freshwater gastropod molluscs originally native to South America, Central America, and the West Indies (Pain, 1972). They were first introduced into Taiwan in Asia in 1979-80, to be cultivated as a high-protein food source for local people and export to industrialized countries (Naylor, 1996). Subsequently, they were

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introduced to other Asian countries, including Japan, the Philippines, China, South Korea, Malaysia, Thailand, Indonesia and Vietnam. In Thailand, *P. canaliculata* were first imported in 1982-83, probably from Japan, Taiwan and the Philippines via Chatuchak weekend market for culturing as aquarium pets. These snail farms were subsequently abandoned, allowing the snails to invade all natural freshwater environments and become a serious pest in paddy fields, particularly in central Thailand (Janyapeth and Archawakom, 1998).

P. canaliculata is a dioecious, sexually dimorphic gastropod, with mature males smaller than mature females (Sitti, 1988; Estebenet and Cazzaniga, 1998). Reproduction is continuous in tropical zones (Martín, Estebenet and Cazzaninga, 2001) and begins at ages of 2-3 months after hatching (Cowie, 2002) or when they have reached a size of > 25 mm (Sawangproh unpubl data). Mating occurs at any time of the day and in all seasons of the year, as long as there is a sufficient supply of water (Naylor, 1996). Females can lay eggs weekly, on substrates from the bare ground of canal banks to vegetation above the water line. Clutch size varies from 400-3000 eggs, depending on the availability of food and the size of the reproductive female (Sitti, 1988; Janyapeth and Archawakom, 1998), indicating that control of snails of reproductive age may be an effective control strategy. The control of apple snails as agricultural pests using various biological control agents has been extensively reviewed (egrets - Acosta and Pullin, 1989; firefly larvae - Kondo and Tanaka, 1989; water bugs - Aroonsrimorakot, 1993; fish - Halwart, 1998; fire ants - Yusa, 2001; carp - Ichinose, Tochihara, Wada, Suguiura and Yusa, 2002; leeches - Aditya and Raut; 2005). However, studies of other organisms that prey on apple snails are still needed.

Common large waders foraging in paddy fields and irrigation canals in central Thailand include herons and egrets (Ardeidae), and a stork species the Asian openbill *Anastomus oscitans* (Boddaert, 1783) that feeds exclusively on mollucs, especially the large native freshwater apple snails *Pila* spp. (Kahl, 1971; McClure, 1974; Lauhachinda 1969; Lekagul and Round, 1991; Poonswad, 1979). However, in response to the spread of the alien *P. canaliculata* in the aquatic environment, the native *Pila* snail population has decreased (Lauhachinda, Senawong, Phongsmas, Udomchoke, Homchan and Makatan, 1999) and the Asian openbill has shifted its diet from *Pila* (Poonswad, 1979) to *P. canaliculata* snails (Khobkhet, 2000). The Asian openbill is believed to be the most effective natural predator of *P. canaliculata* (Khobkhet, 2000 and various farmers pers. comm.). The objectives of this study were to determine the feeding behavior of the Asian openbill on *P. canaliculata* and assess its efficiency as a predator on these snail populations in paddy fields of central Thailand.

MATERIALS AND METHODS

Study area

The study was conducted in Nakhon Pathom Province (14° 00′ N; 100° 14′ E) in central Thailand, where *P. canaliculata* infestation is severe. We conducted our studies on various paddy field blocks, each about 2 acres in area, that occurred alongside 16-20 km of the local road No. 3004 just north of Salaya Campus, Mahidol University (13° 50′ N; 100° 18′ E). We also studied snail abundance and size in Donthong Village (DT; 13° 47′ N; 100° 16′ E) and Sanchao Village (SC; 13° 50′ N; 100° 16′ E), which are about 6 km apart and where no storks had ever been sighted.

Flock size and feeding behavior of storks

We counted the number of storks at 25 blocks of paddy fields along road No. 3004 and recorded their feeding behavior at first sighting through 10x binoculars.

Figure 1. Varying sizes of empty shell of *P. canaliculata* snails left in the paddy fields after stork foraging (H= height; W= width).
Figura 1. Distintos tamaños de conchas vacías de caracoles P. canaliculata *abandonados en los campos de arroz después de excursiones alimenticias de la cigüeña (H= altura, W= anchura).*

Snail abundance and measurement

We distinguished snails that were recently consumed by storks from those that had died earlier, either from stork predation or other causes by looking at the fresh muscle remaining attached to their shells and opercula, or at visceral masses and reproductive organs, such as albumen, found near the shells. We measured the size i.e. height and width of live snails to the nearest 0.01 mm using vernier calipers and then returned them to the same fields, whereas dead shells were brought to the laboratory for measurement (Figure 1). We also studied snail abundance and size in DT and SC.

Effects of storks on snail abundance and size

To determine the effect of the storks on snail abundance, we studied the flock sizes of the storks and snail densities at another seven blocks of paddy fields along road No. 3004, over ten consecutive weeks from late February to April 2006. To determine the effect of Asian openbill predation on snail sizes, we randomly sampled live snails and preyed-on shells using quadrat sampling (quadrat size= 1x1 m, n= 20) after the storks had been feeding in the seven paddy fields from July-April 2006. All paddy fields visited were at the phase of field preparation for rice planting, when rice stalks are burnt and the fields flooded.

Statistical analysis

We analyzed flock sizes of Asian openbill quantitatively and their feeding behavior descriptively. To determine the efficiency of stork in controlling snail populations, we plotted the percentage of snails preyed on by storks against the number of storks visiting each field. Based on flock size, we classified our 25 paddy fields during this study into three classes: 1) 12 low openbill-pressure sites, where visits by storks were known to be frequent but with low abundance (mean flock size 16.4 ± 15.3 storks/flock, n= 12), 2) 13 high openbill-pressure sites, where stork visits were known to be frequent and abundance high (53.0 ± 31.8 storks/flock, n= 13), with 3) one stork-free site (DT-SC) as control. We classified the data of snail sizes from all these paddy fields and correlated them with the three distinct classes based on stork abundance and frequency of stork visit. We categorized the snails into 2 size-classes on their reproductive potential: a) juvenile or non-reproductive (≤ 25 mm high) and adult or mature (> 25 mm high; based on CARLSON, BRÖNMARK, AND HANSSON (2004). Finally, using the Goodness of fit test, we determined snail size preferences as consumed by storks.

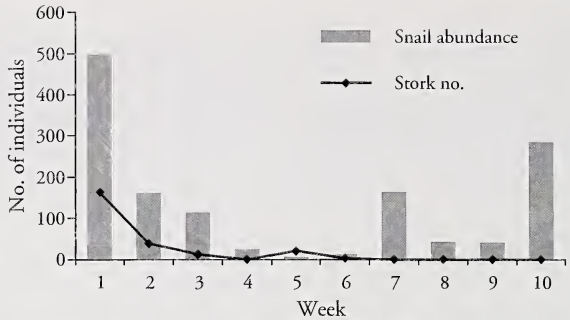

Figure 2. Seven paddy fields showed decreasing snail abundance corresponding to the numbers of foraging storks except the last four weeks when snails were brought into the fields accompanied by water flooding.

Figura 2. Siete arrozales mostraron una disminución de la abundancia de caracoles correspondiente al número de cigüeñas alimentándose, con la excepción de las cuatro últimas semanas, cuando más caracoles fueron llevados a los campos acompañados por inundaciones.

RESULTS

Abundance of the Asian openbill and its feeding behavior

Flock sizes of storks visiting the paddy fields ranged from 6-133 storks per flock (39.5 ± 30.5 storks/flock, n= 24). Stork feeding sites were characterized by flooded fields with water depth ranging from 2.3-16.0 cm (6.4 ± 3.4 cm, n= 24). The flock sizes of storks were positively correlated with snail abundance (live and preyed-on snails) in the fields (rs= 0.6112, p= 0.0082).

We observed that storks searching for snails probed with their bills under and adjacent to floating vegetation and rice stalks. The stork slightly opened its bill and stabbed through the water. When a snail was located, the stork quickly closed its bill, pinned the snail to the ground with its mandibles and then pushed the tip of the lower mandible in to open snail operculum. Once the operculum was opened, the stork then inserted its mandibles, lifted up the snail, shook its bill to free the snail's body from its shell, swallowed the flesh and discarded the shell and operculum.

The effect of the Asian openbill on snail abundance

Snail abundance at seven paddy fields decreased in tandem with decreasing numbers of visiting storks, except during the last four weeks of the study when the fields were flooded with water by farmers, bringing new snails from nearby irrigation canals to settle in the fields (Figure 2). In addition, we found that the percentage of preyed-on snails was positively related to the number of visiting storks (rs= 0.902, p= 0.0001).

The effect of Asian openbill predation on snail sizes

Storks took a longer time (61.0 ± 50.7 seconds, n= 9) to successfully extract large-sized snails (63.2 ± 10.99 mm in length, n= 80) comparing to the few seconds required to swallow each small-sized snail. Storks apparently preferred large-sized (= mature adult) snails to juvenile (= immature small-sized) snails (Table I).

DISCUSSION

Abundance of Asian openbills and their feeding behavior

The flock size of storks varied depending on *Pomacea* snail abundance. All paddy fields visited by storks were burnt and then flooded shortly afterwards. At this time, the habitat allows snails to come out of their hibernating burrows, grow and reproduce, making them available to storks in the fields. We observed

Table I. Summary of snail abundance, preference of snail sizes chosen by storks, and total number of storks at three different sites. (juvenile= immature, adult= mature)
Tabla I. Resumen de abundancias de los caracoles, tamaños de los caracoles preferidos por las cigüeñas, y número total de cigüeñas en tres sitios diferentes. (juvenil= inmaduro; adulto= maduro).

Site	Snail density (nos / 20 m²)	Nº of snails (abundance)	% abundance	Nº of snails preyed on	% preyed on	χ^2	Total nº. storks
The no-stork DT-SC site							
Juvenile (≤ 25 mm)	50	99	32.3	92	15		
Adult (> 25 mm)	104	481	67.7	325	53		
Total	154	617	100	417	68	59.71 (P < 0.001) df= 1	200*
12 low-stork site2							
Juvenile (≤ 25 mm)	64	445	55.1	215	27		
Adult (> 25 mm)	52	362	44.9	240	30		
Total	116	807	100	455	57	25.53 (P < 0.001) df= 1	197
13 high-stork sites							
Juvenile (≤ 25 mm)	74	898	69.6	193	15		
Adult (> 25 mm)	32	393	30.4	264	20		
Total	106	1291	100	457	35	247.48 (P < 0.001) df= 1	688

* Storks visited the site for the first time in several years due to ongoing clearing of previously surrounding orchards.

storks repeatedly visiting the same paddy fields when snails were available, but not fields with high, dense rice stalks where it was possibly difficult to find snails. When searching for snails, the stork probes with its bill in shallow water with the tips of the mandibles slightly open, griping a snail once found and then withdrawing its soft body from the shell. This foraging method is known as tactolocation (COULTER, BALZANO, JOHNSON, KING AND SHANNON, 1989) and is similar to snail-locating behavior in limpkins *Aramus guarauna* (Linnaeus, 1766) (SNYDER AND SNYDER, 1969). Extraction of *Pila* snails by Asian openbill is the same as described by KAHL (1971) where the tip of the lower mandible is usually inserted into the shell and the body dislodged without help from the feet. When feeding on native *Pila* or exotic *P. canaliculata* snails, Asian openbills did not damage the shells from these observations. We also observed Asian openbills discard the albumen glands of mature female snails on the ground where they fed. Possibly, the yolk and eggs of this snail are distasteful, as suggested by SNYDER AND KALE (1983), and the yellowish albumen conspicuous and presumably aposematic to avian predators.

The effect of Asian openbills on apple snail abundance and snail size

Large flocks of openbills could greatly reduce snail populations in paddy fields. Even though the cost of handling, extracting, and consuming large-sized snails was high compared to small-sized snails, storks preferred to eat large-sized snails, apparently because large-sized snails gave more profitability (more energy returns) as predicted by optimal foraging theory (PYKE, 1984). Small-sized snails, which openbills swallowed whole, included much more indigestible material (hard shells and corneous opercula), than the large-sized snails where openbills left the hard shells (Figure 1) and tough opercula in the fields.

The preference for large-sized or adult snails by openbills may negatively affect the reproductive success of the snails, and consequently their population dynamics. On the other hand, the remaining small-sized snails are allowed to grow and reproduce, incidentally making the population a 'sustainable' food source for the storks. Overall, openbills were considered effective agents in controlling the snail population while crops were present; particularly those of reproductive size that would cause most crop damage (Table I).

The limpkin, a tactile predator like the Asian openbill, acts as an agent of disruptive selection on *P. paludosa* snail size by selecting average-sized snails disproportionately more often than small or large snails (Reed and Janzen, 1999). Snail kites *Rostrhamus sociabilis* (Vieillot, 1817), which feed exclusively on *P. paludosa* snails in their native range in Florida, Venezuela, and Colombia, search for prey visually (Beissinger, 1983, 1990; Snyder and Kale, 1983) and seemed to be agents of directional selection against lighter colored snails (Reed and Janzen, 1999). From our observation, storks evidently showed size preference for adult snails over juvenile snails at every study site (Table I).

CONCLUSIONS

The Asian openbill, a resident bird, is an important predator of the mature stage of the invasive alien golden apple snail in Thailand, where rice planting is practiced all year round. Based on snail size and abundance, openbills could potentially feed on and then lower snail population of all sizes, but preferred the large-sized snails that were probably of a more profitable size.

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Ros J. 1976. Catálogo provisional de los Opistobranquios (Gastropoda: Euthyneura) de las costas ibéricas. *Miscelánea Zoológica*, 3 (5): 21-51.

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Synonyms

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Índice

Iberus 30 (1) 2012

Houart R. and Rolán E. The genus *Pradoxa* Fernandes & Rolán, 1993 (Gastropoda: Muricidae) in SãoTomé, Príncipe and Annobón
El género Pradoxa *Fernandes & Rolán, 1993 (Gastropoda: Muricidae) en SãoTomé, Príncipe y Annobón* 1-14

Holyoak D.T. and Holyoak G.A. A taxonomic revision of *Oestophora barbula* (Rossmässler, 1838) and *O. barbella* (Servain, 1880), two Iberian endemic land-snail species (Gastropoda: Trissexodontidae)
Revisión taxonómica de Oestophora barbula *(Rossmässler, 1838) y* O. barbella *(Servain, 1880), dos especies de caracoles terrestres endémicas de la península ibérica (Gastropoda: Trissexodontidae)* 15-40

Pusateri F., Giannuzzi-Savelli R. and Oliverio M. A revision of the Mediterranean Raphitomidae 1: on the sibling species *Raphitoma contigua* Monterosato, 1884 and *Raphitoma spadiana* n. sp. (Gastropoda, Conoidea)
Revisión de los Raphitomidae del Mediteráneo 1: las especies hermanas Raphitoma contigua *Monterosato, 1884 y* Raphitoma spadiana *n. sp. (Gastropoda, Conoidea)* 41-52

Rolán E. and Gori S. New species of neogastropods from the islands of the Gulf of Guinea, West Africa
Nuevas especies de neogasterópodos de las islas del golfo de Guinea, África occidental ... 53-66

Moreno D. The genus *Gibberula* (Gastropoda, Cystiscidae) in the Cape Verde Islands with the description of a new species
El género Gibberula *(Gastropoda, Cystiscidae) en el archipiélago de Cabo Verde con la descripción de una nueva especie* 67-83

Campani E., Bartolini S. and Spanu M.T. *Alvania garrafensis* Peñas & Rolán 2008 (Gastropoda: Rossoidae) from Croatian waters
Alvania garrafensis *Peñas & Rolán 2008 (Gastropoda: Rossoidae) en aguas croatas* 85-89

Holyoak D.T. and Holyoak G.A. A review of species-limits in some *Cryptazeca* (Gastropoda: Azecidae)
Reconsideración de los límites entre especies en Cryptazeca *(Gastropoda: Azecidae)* ... 91-102

Calado G., Soares C. and Neves R.C. Reproduction in two sympatric Iberian nudibranch species (Gastropoda: Opisthobranchia) with contrasting development types
Reproducción en dos especies simpátricas de nudibranquios (Gastropoda: Opisthobranchia) de la Península Ibérica con tipos de desarrollo alternativos 103-110

Sawangproh W., Round P.D. and Poonswad P. Asian openbill stork *Anastomus oscitans* as a predator of the invasive alien gastropod *Pomacea canaliculata* in Thailand
La cigüeña asiática de pico abierto Anastomus oscitans *como un depredador del caracol manzana* Pomacea canaliculata, *especie exótica invasora en Tailandia* 111-117

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Iberus

Vol. 30 (2)

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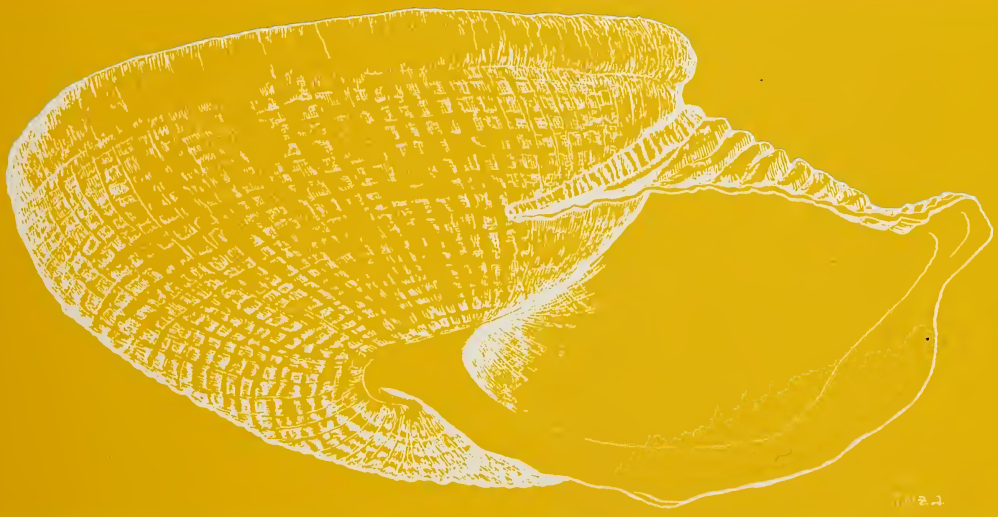

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Iberus gualtieranus (Linnaeus, 1758), una especie emblemática de la península Ibérica, que da nombre a la revista. Dibujo realizado por José Luis González Rebollar "Toza".

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Oscilla galilae, a new species of Pyramidellidae (Mollusca, Gastropoda, Heterobranchia) from the Eastern Mediterranean

Oscilla galilae, una nueva especie de Pyramidellidae (Mollusca, Gastropoda, Heterobranchia) del Mediterráneo oriental

Cesare BOGI*, Selahattin Ünsal KARHAN** and Mehmet Baki YOKEŞ***

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ABSTRACT

The finding of some specimens of a small pyramidellid along the Mediterranean coasts of Turkey, Israel and Cyprus, previously reported off the south-eastern coast of Turkey (Buzzurro & Greppi, 1996; Buzzurro *et al.*, 2001) as *Hinemoa cylindrica* (de Folin, 1879), induced us to revise this identification. *Hinemoa cylindrica* is of Indo-Pacific origin and has been originally attributed to the genus *Jaminea* Brown, 1827 (not Risso, 1826). Later, it has been transferred to the genus *Hinemoa* Oliver, 1915 (Buzzurro *et al.*, 2001). However, some details of its morphology do not agree with the description and figure of *Jaminea cylindrica* given by de Folin (1879). For a more suitable generic placement, we compared the species to the members of some closely resembling taxa in Pyramidellidae Gray, 1840 (e.g., *Cingulina*, A.Adams, 1860, *Hinemoa* Oliver, 1915, *Miralda* A. Adams, 1864, *Odetta* de Folin, 1870 and *Oscilla* Adams A., 1861). Its morphological characteristics have led us to assign it to the genus *Oscilla* as a new species.

RESUMEN

El hallazgo de algunos ejemplares de un pequeño piramidélido en las costas mediterráneas de Turquía, Israel y Chipre, previamente citado en la costa sur-oriental de Turquía (Buzzurro y Greppi, 1996;. Buzzurro et al, 2001) como *Hinemoa cylindrica* (de Folin, 1879), llevó a revisar esta identificación. *Hinemoa cylindrica* es de origen Indo-Pacífico y ha sido atribuida originalmente al género *Jaminea* Brown, 1827 (non Risso, 1826). Posteriormente, se ha transferido al género *Hinemoa* Oliver, 1915 (Buzzurro et al., 2001). Sin embargo, algunos detalles de su morfología no cuadran con la descripción y la figura de *Jaminea cylindrica* dada por de Folin (1879). Con vistas a una identificación genérica más adecuada, se compararon la especie con miembros de algunos grupos taxonómicos más similares en Pyramidellidae Gray, 1840 (por ejemplo, *Cingulina*, A.Adams de 1860, *Hinemoa* Oliver, 1915, *Miralda* A. Adams, 1864, *Odetta* de Folin de 1870 y *Oscilla* A. Adams, 1861). Sus características morfológicas nos han llevado a describir una nueva especie en el género *Oscilla*.

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INTRODUCTION

Ongoing malacological research and the examination of numerous sediment samples collected along the coasts of Israel, in particular by dredging operations carried out off the port of Haifa, have produced many interesting discoveries including numerous species of Indo-Pacific origin (e.g., Bogi & Galil, 1997, 2000, 2007, 2009). This time we recorded the discovery of some specimens of a pyramidellid gastropod already reported from the south-eastern coast of Turkey (Buzzurro, Hoarau, Greppi & Pelorce, 2001) and identified by the authors as *Jaminea cylindrica* de Folin, 1879, assigned to the genus *Hinemoa* Oliver, 1915, albeit tentatively. This species, whose type locality indicated by de Folin (1879) is Borneo (South China Sea) has a wide Indo-Pacific distribution, but has not yet been reported from the Red Sea (Dekker & Orlin, 2000). However, morphological characteristics of newly found specimens make them easily distinguishable from de Folin's species. Upon examination, morphological characteristics of the shells have led us to assign them to an undescribed species of the genus *Oscilla* A. Adams, 1861, but not *Hinemoa*. A description of the new species along with a discussion of its taxonomic affinities is presented herein.

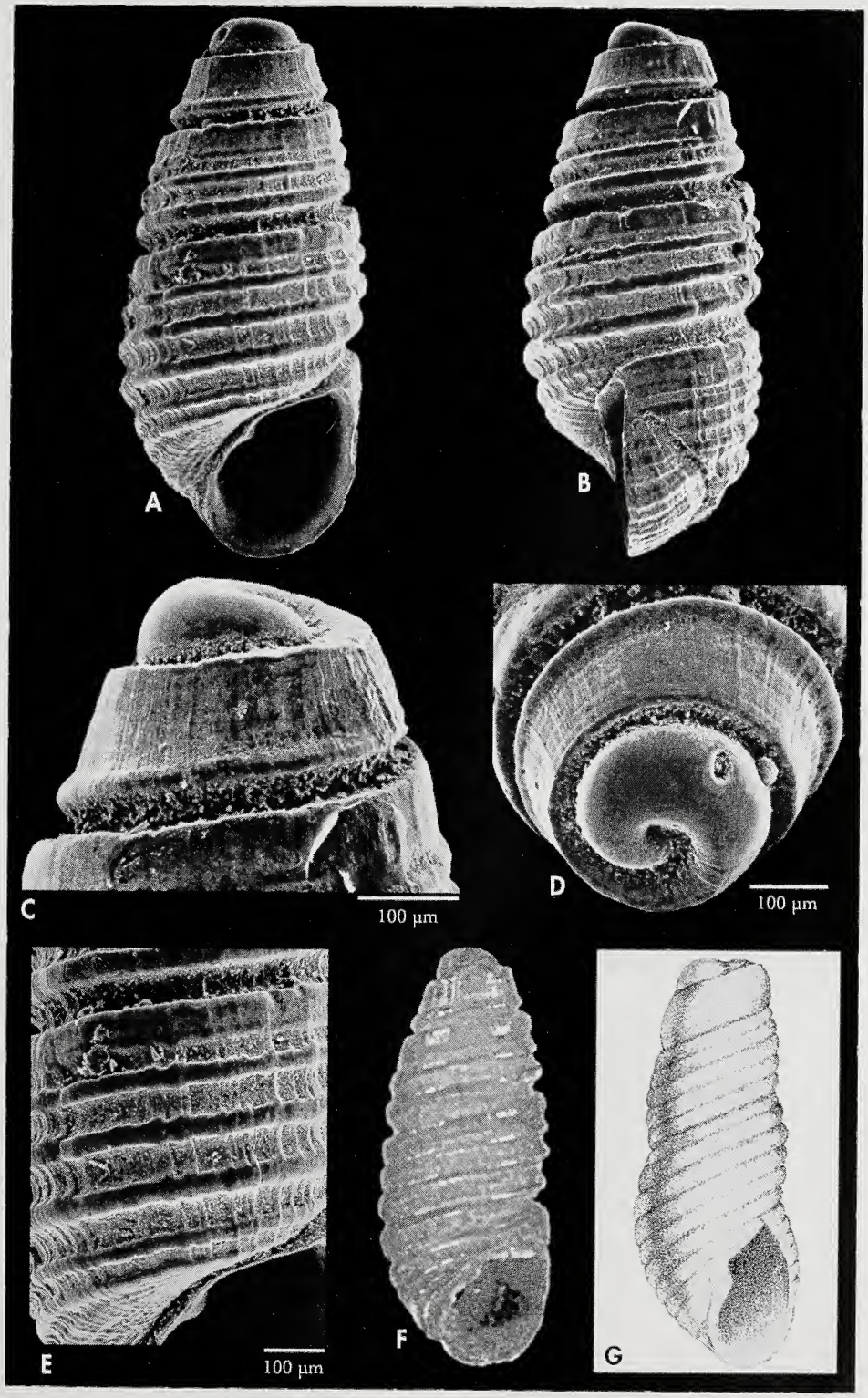
TAXONOMY

Pyramidelloidea Gray, 1840
Pyramidellidae Gray, 1840
Oscilla A. Adams, 1861

Oscilla galilae n. sp. (Fig. 1A-F)

Type material: The holotype (1.40 × 0.65 mm) (Fig. 1A-E) is deposited in the National Collections of Natural History at Tel Aviv University with the catalog number TAU MO 73668. The paratypes are deposited in the following collections: paratypes A (Fig. 1F) and E (1.55 × 0.68 mm and 1.27 × 0.60 mm, respectively) in the collection of S.Ü. Karhan and M.B. Yokeş (Istanbul, Turkey); paratypes B, C and D (1.36 × 0.61 mm, 1.20 × 0.55 mm and 1.35 × 0.62 mm, respectively) in the collection of C. Bogi (Livorno, Italy); paratypes F and G (1.71 × 0.70 mm, 1.52 x 0.65 mm, respectively) in the collection S. Raveggi (Firenze, Italy).
The holotype comes from dredging carried out in Haifa Bay, Israel (32° 54.544′ N, 35° 04.093′ E) at 10.5 m depth on 31.V.2009; paratype A from sediments collected manually using SCUBA in Carmel Reef, off Haifa (32° 50.529′ N, 34° 56.637′ E) at 21 m depth on 19.XI.2009; paratypes B and C from material collected by dredging carried out in the Port of Haifa (32° 54.433′ N, 35° 01.661′ E) at 25 m depth on 14.IV.2010; paratype D collected from the Port of Haifa (32° 54.357′ N,35° 02.793′ E) at 20 m depth on 12.X.2010; paratype E from sand sample collected using SCUBA off Taşucu, Mersin, Turkey (36° 14.530′ N, 33° 48.359′ E) at 5 m depth on 03.IX.2007, and paratypes F and G off Capo Greco, Cyprus (34° 58.3618′ N, 34° 04.3682′ E) at 30 m depth on August 2011. The holotype and paratypes B, C and D were collected complete with soft parts.
Type locality: Sandy bottoms in and around the Port of Haifa (Mediterranean coast of Israel) at depths between 10 and 25 m.

(Right page) Figure 1. A-E: *Oscilla galilae* n. sp., holotype (TAU MO 73668), actual height 1.40 mm. A: frontal view; B: lateral view; C: protoconch, lateral view; D: protoconch, apical view; E: detail of the sculpture; F: paratype A, actual height 1.55 mm, frontal view. G: *Jaminea cylindrica*, original illustration given by de Folin (1879).
(Página derecha) Figura 1. A-E: Oscilla galilae *n. sp., holotipo (TAU MO 73668), altura real 1,40 mm. A: vista frontal; B: vista lateral; C: protoconcha, vista lateral; D: protoconcha, vista apical, E: detalle de la escultura, F: paratipo A, altura real 1,55 mm, vista frontal. G:* Jaminea cylindrica, *ilustración original por* de Folin *(1879).*


A
B
C
100 µm
D
100 µm
E
100 µm
F
G

Etymology: The new species is named after Dr. Bella S. Galil, in recognition of her extensive contributions to taxonomy and to knowledge of the fauna from the Eastern Mediterranean Sea. The epithet is a noun in the genitive case.

Description: Shell of medium size for genus, attaining 1.71 mm height, elongate, cylindrical or slightly oval; color uniformly whitish. Teleoconch consisting of about three whorls, somewhat convex in profile, separated by well-marked and slightly oblique suture. Protoconch smooth, flat and heterostrophic, type C (VAN AARTSEN, 1977), with about 0.5 whorl; diameter about 300 μm in holotype. The first whorl of teleoconch with two spiral ribs, visible only by transparency inside the spire. Spiral sculpture consisting of very pronounced spiral ribs, rounded, almost uniform that tends to increase with growth. Interspaces between the ribs narrower than the ribs themselves and crossed by numerous axial lamellas. Aperture about one-third of total height, oval, with a thin outer lip; columellar tooth distinct; umbilicus absent.

Distribution: Geographical distribution of the species seems to be restricted to shallow sublittoral areas in a few localities on Israeli, Turkish and Cypriot coasts in the eastern Mediterranean Sea.

Discussion: After examination of the present specimens (fig. 1 A-F), our attention was drawn (J. Pelorce, pers. comm.) to the fact that they correspond perfectly to those previously collected on the Turkish coast and identified as *Hinemoa cylindrica* (de Folin, 1879), a new combination proposed for *Jaminea cylindrica* by BUZZURRO *ET AL.* (2001).

However, we have been able to note some morphological details that do not agree with the description and illustration of *Jaminea cylindrica* given by de Folin. The original description of *J. cylindrica* is as follows (DE FOLIN, 1879: 266):

"Testa minutissima, sucylindrica, satis lata, paulò elongata, alba; anfractus embryonales II, obliquis apice occulto; normales III, in longitudine rapide augentes, liris validis spirali bus ornati; ultimo maximo, 1/3 testae aequante; apertura ovata paulò obliqua, margine columellare undulato, intus dentato.

Long.:1 mm 4; lat.: 0 mm 5.

Très petite espèce, fort jolie et fort bien caractèrisée par la position oblique de ses tours embryonnaires dont le sommet parait caché; puis par sa forme presque cylindrique, peu allongèe et relativament large. Les tours normaux, au nombre de trios, s'allongent rapidement, en demeurant presque de la meme largeur. Ils sont ornès de cordons spiraux proportionnellement forts et bien exprimès. L'ouverture est ovale, lègèrement oblique; son bord columellaire est nodulè par les courbes qu'il dècrit; il est armé, au dedans et vers son milieu, d'une dent assez sensible."

Oscilla galilae n. sp. and *Jaminea cylindrica* differ in several features. In *O. galilae* there is a dense axial sculpture consisting of small lamellae in the interspaces between the spiral ribs (Fig. 1E), whereas in *J. cylindrica* spiral ribs are in contact with each other without any interspaces bearing axial sculpture (Fig. 1G). The new species differs from *J. cylindrica* also in general shape of the shell as the latter is more cylindrical, its top whorl is more obtuse, and its suturing is more oblique (de Folin, 1879; pl.9, fig.5). Spiral sculpture also differs as the new species has more prominent spiral cords than those of *J. cylindrica*.

BUZZURRO *ET AL.* (2001) have also noticed these discrepancies, but all the same, probably taking into account the cylindrical profile, well-marked columellar tooth, flat protoconch and smooth first whorl of teleoconch, they have assigned their specimens to the species described by de Folin (1879). Unfortunately it was not possible to compare our specimens with the holotype of *J. cylindrica* as it is not present in the collection of de Folin stored in MNHN (Paris, France) and is presumed to be lost (V. Heros, pers. comm.). Since the type material is no longer available, *J. cylindrica* should therefore be considered a nomen dubium.

In the family Pyramidellidae Gray, 1840 there are many morphologically similar genera, some of which show only minor differences from others. These differences are often insufficient to justify

their generic validity but perhaps sufficient to place them in subgenus status. In the original description of the genus *Hinemoa* "*Shell ovate. Protoconch 1-whorled. Aperture ovate. Columella with a feeble plait. Sculpture of spiral ribs only*", where the type species is *Hinemoa punicea* (Oliver, 1915: 531, pl. X, fig. 22), Oliver clearly referred to a sculpture consisting only of spiral ribs. In the description of the type species, *H. punicea* (Oliver, 1915: 531, pl. X, fig. 22), the author also pointed out the well recognized and rounded spiral ribs with intervals without striae, which is not the case for the specimens of *O. galilae* n. sp.

With regard to the details of the sculpture outlined in the description, the new species should be assigned to the genus *Oscilla* A. Adams, 1861. In their list of species found in Taşucu (south-eastern Turkey), BUZZURRO & GREPPI (1996) have also provisionally identified this species as *Oscilla* sp. The genus *Oscilla* closely resembles the genus *Miralda* A. Adams, 1864, in having prominent spiral sculptures, but *Miralda* has small axial ribs especially in the upper part of the whorls and a protoconch of type A, which is not the case in *Oscilla* (see ROLAN & FERNANDES, 1993: figs. 1, 3-7). The genus *Odetta* de Folin, 1870, also has pronounced spiral ribs, but has smooth interspaces between the ribs and a protoconch of type A (VAN AARTSEN, 1984). The genus *Cingulina* A. Adams, 1860 also resembles *Oscilla*, in having sculpture consisting of many strong spiral cords covering whorls of the spire. These two genera differ in three main features; Species of the genus *Cingulina* are much more elongated than those of *Oscilla* and they do not have a columellar tooth.

In agreement with BUZZURRO *ET AL.* (2001), the genus *Oscilla* is so closely allied to the genus *Hinemoa*, that the latter may be better considered as a subgenus of *Oscilla*. These two taxa differ from each other principally in having a different arrangement of spiral ribs, uniform in *Oscilla* and not uniform in *Hinemoa*, striated interspaces in *Oscilla* and smooth ones in *Hinemoa*, and some other differences of minor importance.

The only species belonging to the genus *Oscilla* present in the Mediterranean is *O. jocosa* Melvill, 1904, originally described from the Gulf of Oman and repeatedly collected along the Mediterranean coasts of Israel (VAN AARTSEN, BARASH & CARROZZA, 1989; BOGI & GALIL, 1999; BOGI & GALIL, 2006). This species is distinguished easily from *O. galilae* by its greater dimensions, having a more conical shell, flat rather than convex whorls, three spiral ribs per whorl with the top two shorter, more prominent sculpture in interspaces especially in the early whorl and protoconch axis with an angle of 135° to the axis of the shell.

Of the four species described from the Red Sea by HORNUNG & MERMOD (1924-1925), namely *Cingulina* (*Odetta*) *bellardii*, *C.*(*O.*) *beccarii*, *C.*(*O.*) *nodulosa* and *C.*(*O.*) *appeliusi*, only the latter vaguely resembles *O. galilae*, from which it is distinguished mainly by its pupoid profile and different embryonic whorls.

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A reassessment of the species of *Truncatellina* (Gastropoda: Vertiginidae) in the Iberian Peninsula and North-west Africa

Revisión de las especies de *Truncatellina* (Gastropoda: Vertiginidae) en la Península Ibérica y NO de África

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ABSTRACT

Taxonomy and distribution are reviewed for the tiny land snails of the genus *Truncatellina*, mainly in SW. France, the Iberian Peninsula and NW. Africa (Morocco and Algeria). *T. beckmanni* Quintana, 2010 was recently named as an endemic of Menorca (Balearic Islands). The same distinctive but rather variable species occurs in Portugal and Andalucia. *T. callicratis* is shown to be the commonest and most widespread species in Iberia and NW. Africa. Its southern populations in the Algarve, Andalucia, Morocco and Algeria mainly consist of shells lacking apertural teeth, whereas those in most populations further north have three small teeth. The sequence of development of apertural teeth in this species is discussed in detail. Shells of coexisting *T. callicratis* with and without teeth do not differ in other characters and partial development of teeth is common in many populations, so they are all regarded as conspecific. On this basis, several taxa with the apertural teeth reduced or lacking are treated as synonyms of *T. callicratis*, from England, Croatia, Greece, Algeria, Tunisia and Libya. Those Iberian and NW. African shells lacking teeth have hitherto often been misidentified as *T. cylindrica*, but this appears to be a predominantly northern species (recorded south to the French Pyrenees) differing in other shell characters. *T. arcyensis* Klemm, 1943 intergrades with *T. cylindrica* and is therefore treated as a synonym of that species. An identification key to the W. European and NW. African species is presented, based on characters of adult shells.

RESUMEN

Se revisan la taxonomía y distribución de los pequeños caracoles del género *Truncatellina*, principalmente del SO de Francia, la Península Ibérica y el NO de África (Marruecos y Argelia). *T. beckmanni* Quintana, 2010 fue recientemente descrita como un endemismo de Menorca (Islas Baleares). La misma característica, aunque bastante variable especie está presente también en Portugal y Andalucía. *T. callicratis* ha resultado ser la especie más común y de más amplia distribución en Iberia y NO de África. Sus poblaciones más meridionales, en el Algarve, Andalucía, Marruecos y Argelia, consisten principalmente en conchas con la abertura desprovista de dientes, mientras que la mayoría de las poblaciones que viven más al norte tienen tres pequeños dientes. La secuencia del desarrollo de los dientes de la abertura en esta especie se discute en detalle. La conchas de *T. callicratis* con o sin dientes que coexisten, no se distinguen por otros caracteres y el desarrollo parcial de dientes en común en muchas poblaciones, por lo que todas ellas son consideradas como conespecíficas. Sobre esta base, numerosos táxones de Inglaterra, Croacia, Grecia, Argelia, Túnez y Libia con los

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dientes aperturales reducidos o ausentes son considerados sinónimos de *T. callicratis*. Las conchas ibéricas y del NO de África sin dientes han sido a menudo clasificadas como *T. cylindrica*, aunque ésta resulta ser una especie predominantemente del norte, que se distribuye hacia el sur hasta los Pirineos franceses y que difiere en otros caracteres de la concha. *T. arcyensis* Klemm, 1943 está solapada con *T. cylindrica*, por lo que se considera sinónimo de esta especie. Se presenta una clave de identificación de las especies de Europa occidental y NO de África, basada en caracteres de conchas adultas.

INTRODUCTION

The genus *Truncatellina* comprises numerous species of tiny land snails that occur in the Palearctic and Afrotropical Regions with a few in the Indo-Malayan region. The only comprehensive review was by Pilsbry (1920-1921), which brought some order to usage of names from what he termed the "semi-mythical" period (1774-1821) and provided a detailed monograph of all the taxa then known. Seventeen additional species have been named in the past ninety years, from Europe (Klemm, 1943; Štamol, 1995; Triantis, Pokryszko, Vardinoyannis and Mylonas, 2004; Quintana, 2010), Macaronesia (Hutterer and Groh, 1991), N. Africa (Zilch, 1962), tropical Africa (e.g. Van Bruggen, 1994) and Asia (e.g. Pokryszko, Auffenberg, Hlavac and Naggs, 2009).

In north-western and central Europe the taxonomy of the genus now seems to mostly be well understood and stable (cf. Kerney and Cameron, 1979; Falkner, Bank and von Proschwitz, 2001; Falkner, Ripken and Falkner, 2002; Fauna Europaea Database Project, 2011). Recent published accounts for the Iberian Peninsula mainly report two species that are widespread in Europe, *T. callicratis* (Scacchi, 1833) and *T. cylindrica* (A. Férussac, 1807). These are mapped as about equally common in N. Spain (Altonaga, Gómez, Martín, Prieto, Puente and Rallo, 1994), both are shown as widespread in Andalucia (Ruiz, Cárcaba, Porras and Arrébola, 2006) and both are listed as occurring in Catalonia (Bech, 1990) and the Comunidad Valenciana (Martínez-Ortí and Robles, 2003). For Portugal, Nobre (1941: 152-153) reported only *T. cylindrica* (as *Vertigo muscorum* (Draparnaud)), at numerous localities from Trás-os-Montes to the Algarve. In addition, *T. claustralis* (Gredler, 1856) is reported from Albacete Province and the Comunidad Valenciana (Martínez-Ortí and Robles, 2003: 84-85) and perhaps Catalonia (Bech, 1990), *T. doumeti* Letourneux and Bourguignat, 1887 from near Barcelona (Altimira, 1969, cited by Bech, 1990) and *T. beckmanni* has recently been named from Menorca where it was regarded as an endemic (Quintana, 2010). There is very little modern information published on *Truncatellina* in NW. Africa, from where old reports summarised by Pilsbry (1920-1921) refer to *T. cylindrica* (Morocco, Algeria and Tunisia), *T. doumeti* (type-locality in Tunisia) and *T. callicratis* [as *T. rivierana* (Benson, 1854)] (in Algeria).

In our material from Spain, Portugal, Morocco and Algeria *T. callicratis* is the only common species, with no definite *T. cylindrica* from anywhere south of the French side of the Pyrenees. It appears that the common Iberian and NW. African forms of *T. callicratis* lacking teeth in the shell aperture have been widely misidentified as *T. cylindrica*. The only other species we found was *T. beckmanni*, with specimens from C. and S. Portugal and Andalucia. This taxon varies considerably in size, with small specimens from Portugal exactly matching topotypical *T. beckmanni* from Menorca. We provide data on the shell characters of *T. beckmanni*, *T. callicratis* and *T. cylindrica* and discuss their taxonomy. An identification key to the W. European and NW. African species is also presented, based on characters of adult shells.

PILSBRY (1920-1921) used an essentially typological species concept applied to shell specimens and some subsequent studies have used similar methods. However, KENNARD AND WOODWARD (1923) paid more attention to variability in shell characters in reviewing the British species and some recent studies such as that by QUINTANA (2010) have considered character variation in detail. The scanty information available on genital anatomy of the genus (WATSON, 1923; STEENBERG, 1925; POKRYSZKO, 1990), discloses very simple distal genitalia that seem unlikely to provide useful taxonomic characters. In the absence as yet of data from molecular genetics, it would appear that the best current approaches to judging species-limits in the genus may consist in studying variability of shell characters within and between populations, along with any evidence of sympatric occurrence of taxa.

MATERIAL AND METHODS

Field collections by the authors were made by direct searching, usually accompanied by sieving plant debris and surface soil using nested 2.0 and 0.5 mm mesh sieves. The resulting "fines" were then usually searched at low magnifications using a stereo-microscope. All shells found were retained to avoid possible bias in favour of large or well preserved specimens. Attempts were made to collect population samples with numerous shells from as many sites as possible. Prior to 2001 localities were judged from vehicle mileage readings in conjunction with road maps at 1:200,000 to 1:350,000 scales and altitudes were mainly measured using a barometric altimeter. From 2007 onwards most localities and altitudes recorded by DTH and GAH were obtained using a hand-held Garmin GPS accurate to within 10 metres. Habitat notes (including bedrock type and vegetation) and associated Mollusca were recorded at almost all of the sites.

Shells of adults were distinguished from those of immatures by possession of a markedly expanded and somewhat thickened edge to the peristome. Only adult shells were used for shell measurements and descriptions of apertural teeth. Occasional individual shells that had grown very high without developing a reflected or thickened peristome were not used.

The literature often refers to the teeth as denticles when they are small, or folds when they are large and elongate, but all such protuberances are termed teeth in this account. A shorthand notation was used in scoring teeth of individual shells, taking the names in alphabetical order as columellar, palatal, parietal; thus *e.g.*, 111= all three teeth present, 000= no teeth present, 101= columellar and parietal present but not palatal. Shells were not scored for presence or absence of teeth unless the normal locations of all three teeth were clear of dirt, soil or detritus so they could be seen clearly through the shell mouth. Presence of a palatal tooth was not scored by looking at the back of the mouth, since a very small tooth would often be invisible through the shell wall. Studies of apertural teeth were made using a Meiji RZ series stereomicroscope, intense illumination from a Schott KL 1500 light source via twin fibre-optic swan necks, and tilting or rotating the shells using a very fine, damp paintbrush.

Shell height was measured as the maximum from the top of the protoconch to the lowest part of the outer basal edge of the peristome; shell breadth as the maximum width of the spire, with the shell aperture facing upwards. The measurements were made using Infinity Analyze© software on images taken with an Infinity 1 camera on the same stereomicroscope. The measurements on the images were reproducible to ± <0.01 mm, but unavoidable slight tilting of the shells almost certainly caused minor additional loss of precision. Drawings were made using a Meiji drawing tube.

A representative list of the material studied is given in the Appendix, including specimens from England, C. and E. France and Malta used for comparisons; the full list is available from the authors. Abbreviations used for collections addi-

tional to those listed for the Appendix are as follows: ANSP= Academy of Natural Sciences of Philadelphia, U.S.A., SMF= Senckenberg Museum, Frankfurt, Germany.

RESULTS, WITH COMMENTS ON TAXONOMY AND HABITATS

Table I gives shell measurements of Iberian samples of *T. beckmanni* and *T. callicratis*, with comparative measurements of *T. cylindrica* from the French Pyrenees; Table II presents data on occurrence of apertural teeth in samples of >7 shells of *T. callicratis*; Fig. 1 gives drawings of representative shells of *T. beckmanni*, *T. callicratis* and *T. cylindrica*; Fig. 2 illustrates apertural teeth of *T. beckmanni* and *T. callicratis*; Fig. 3 is a graph of mean shell height versus mean shell breadth for selected populations. Distribution maps based on specimens examined are given as Figs. 4-6, for *T. beckmanni*, *T. callicratis* and *T. cylindrica* respectively. The synonymy presented below consists mainly of selected names that we discuss; PILSBRY (1920-1921) presented much more complete lists.

Genus *Truncatellina* R.T. Lowe, 1852

Type species: *Pupa linearis* R.T. Lowe, 1852, by monotypy.

Truncatellina beckmanni Quintana, 2010

Truncatellina beckmanni Quintana, 2010, Spira, 3, p. 153, figs. 4A-C. Type locality: Lloc de Monges (Ciutadella de Menorca, Illes Baleares). Holotype: Museu Diocesà de Menorca MDM-2703 (not seen).

Diagnostic characters: Aperture with three well developed teeth in all mature shells, the palatal tooth visible in frontal view of shell mouth, the parietal tooth large, well developed, forming tall lamellar ridge descending into aperture (Figs. 2A, C). Differs from toothed forms of *T. callicratis* in stronger teeth, relatively short and wide shell (height/breadth 1.4-1.9; shell breadth 0.79-1.00 mm, population means 0.85-0.94 mm); ribs on body whorl usually widely spaced.

Our specimens from Portugal and Andalucia (Figs. 1-4, Appendix) have been closely compared with topotypes of *T. beckmanni*. These populations have larger average shell dimensions than those from Menorca, but three of the smaller-shelled samples among them demonstrate much overlap (site P46 in Beira Litoral, sample 10747 from Estremadura, site P118 in Algarve) (Table I, Figs. 1, 3). The size and form of the apertural teeth and ribbing on the shells in Menorcan material can also be matched in samples from Portugal and Andalucia. The original description of *T. beckmanni* (QUINTANA, 2010: 155) states that "A diferencia de *T. purpuraia*, *T. beckmanni* no presenta callo parietal", but Fig. 4A in the same paper suggests there is at least a weakly developed parietal callus. Our material from Portugal and Andalucia often has a definite parietal callus, but sometimes none, its strength often appearing to correspond to the thickness and degree of calcification of the whole shell. Since Menorcan specimens are within the overall range of variation of all characters in samples from Portugal and Andalucia, we have no hesitation in regarding them all as conspecific.

T. beckmanni coexists with *T. callicratis* at several localities in Portugal (Beira Litoral, Estremadura) and Andalucia (Prov. Málaga), the detailed data being given in the Appendix. Where they coexist, all good adult specimens are readily assigned to one species or the other using characters set out in our diagnosis above and key below. Thus, *T. beckmanni* invariably has a longer parietal tooth, forming a tall lamella when fully developed (Fig. 2) and normally a shorter, wider shell with more widely spaced ribs (Figs. 1, 3, Table I).

T. beckmanni most closely resembles *T. klemmi* Zilch, 1962 (type-locality Cyrenaica,

Table I. Shell measurements for *Truncatellina beckmanni*, *T. callicratis* and *T. cylindrica*.
Tabla I. Medidas de la concha de Truncatellina beckmanni, T. callicratis *y* T. cylindrica.

Species	Sample no.	Region	Locality	N		Shell height	Shell breadth	height/ breadth	Teeth
Truncatellina:									
beckmanni		Menorca	data from Quintana (2010)	92	Min.	1.240	0.790		
				92	Max.	1.600	0.940		
				92	Mean	1.400	0.860	1.627	
				92	S.D.	0.080	0.034		
beckmanni	11296	Menorca	Lloc de Monges	1		1.298	0.842	1.542	
				1		1.384	0.844	1.640	
beckmanni	1984.90.2	Prov. Córdoba	2 km NE. of Cabra	1		1.511	0.896	1.686	
				1		1.519	0.921	1.649	
beckmanni	6989	Prov. Málaga	Sierra de San Jorge	4	Min.	1.593	0.913	1.708	
				4	Max.	1.658	0.966	1.770	
				4	Mean	1.630	0.940	1.735	
				4	S.D.	0.027	0.027	0.028	
beckmanni	1984.92.1	Prov. Málaga	1 km NW. of Puerto de Las Pedrizas	1		1.599	0.977	1.637	
beckmanni	P117	Algarve	E. of Santa Barbara de Nexe	8	Min.	1.467	0.890	1.645	
				8	Max.	1.618	0.937	1.780	
				8	Mean	1.544	0.907	1.703	
				8	S.D.	0.050	0.019	0.046	
beckmanni	P118	Algarve	3 km NNW. of Moncarapacho	20	Min.	1.336	0.832	1.606	
				20	Max.	1.630	0.913	1.777	
				20	Mean	1.474	0.870	1.694	
				20	S.D.	0.067	0.022	0.058	
beckmanni	1984.408.1	Algarve	5 km E. of Santa Caterina	1		1.406	0.851	1.652	
beckmanni	10747	Estremadura	Portinho da Arrábida	3	Min.	1.362	0.829	1.586	
				3	Max.	1.494	0.859	1.802	
				3	Mean	1.430	0.849	1.686	
				3	S.D.	0.066	0.017	0.109	
beckmanni	1984.419.12	Estremadura	7 km NE. of Portinho da Arrábida	1		1.373	0.878	1.564	
beckmanni	1984.418.1	Estremadura	5 km NE. of Portinho da Arrábida	1		1.430	0.885	1.616	
				1		1.483	0.894	1.659	
				1		1.526	0.924	1.652	
beckmanni	2007/16	Estremadura	Serra da Arrábida	1		1.459	0.885	1.649	
				1		1.659	0.946	1.754	
beckmanni	2010/P43	Estremadura	Fórnea	1		1.645	0.919	1.790	
beckmanni	P162	Estremadura	S. Bartolomeu	1		1.381	0.842	1.640	
beckmanni	2010.P64	Estremadura	1.5 km SE. of Livramento	64	Min.	1.263	0.843	1.467	
				64	Max.	1.645	0.999	1.819	
				64	Mean	1.509	0.911	1.655	
				64	S.D.	0.078	0.032	0.075	

Table I. Continuation.
Tabla I. Continuación.

Species	Sample no.	Region	Locality	N		Shell height	Shell breadth	height/ breadth	Teeth
beckmanni	2010.P41	Ribatejo	SE. of Moitas Venda	93	Min.	1.350	0.869	1.453	
				93	Max.	1.807	1.008	1.933	
				93	Mean	1.560	0.928	1.682	
				93	S.D.	0.080	0.028	0.084	
beckmanni	2008/P8	Beira Litoral	Capela Nostra Senora Covões	1		1.415	0.867	1.632	
beckmanni	2010/P46	Beira Litoral	1 km SW. of Ateanha	11	Min.	1.310	0.842	1.495	
				11	Max.	1.575	0.932	1.812	
				11	Mean	1.458	0.882	1.655	
				11	S.D.	0.086	0.028	0.108	
beckmanni	2010.P45	Beira Litoral	Vale da Couda	4	Min.	1.470	0.852	1.670	
				4	Max.	1.642	0.930	1.766	
				4	Mean	1.546	0.904	1..710	
				4	S.D.	0.073	0.036	0.044	
beckmanni	2010.P75	Beira Litoral	2 km WNW. of Ansião	12	Min.	1.424	0.880	1.525	
				12	Max.	1.661	0.975	1.825	
				12	Mean	1.522	0.916	1.663	
				12	S.D.	0.065	0.024	0.091	
beckmanni	2010.P73d	Beira Litoral	1.5 km WNW. of Ansião	10	Min.	1.539	0.904	1.640	
				10	Max.	1.712	0.960	1.840	
				10	Mean	1.605	0.930	1.727	
				10	S.D.	0.056	0.018	0.076	
callicratis	2011.P117	Algarve	2 km E. of Santa Barbara de Nexe	8	Min.	1.531	0.802	1.871	toothless
				8	Max.	1.918	0.894	2.145	
				8	Mean	1.649	0.839	1.966	
				8	S.D.	0.129	0.038	0.106	
callicratis	2011.P118	Algarve	3 km NNW. of Moncarapacho	59	Min.	1.261	0.764	1.572	toothless
				59	Max.	1.964	0.868	2.294	
				59	Mean	1.566	0.827	1.894	
				59	S.D.	0.129	0.022	0.133	
callicratis	2011.P104	Algarve	E. end of Rocha da Pena	22	Min.	1.337	0.765	1.737	mainly toothless
				22	Max.	1.639	0.827	2.016	
				22	Mean	1.502	0.797	1.884	
				22	S.D.	0.066	0.015	0.072	
callicratis	10750	Estremadura	Portinho da Arrábida	4	Min.	1.493	0.793	1.883	toothless
				4	Max.	1.709	0.835	2.047	
				4	Mean	1.564	0.805	1.941	
				4	S.D.	0.098	0.020	0.073	
callicratis	2010.P32	Estremadura	Serra de Montejunto	1		1.784	0.889	2.007	3-toothed
callicratis	P162	Estremadura	S. Bartolomeu	1		1.521	0.856	1.777	3-toothed
callicratis	2009.P14	Estremadura	above Grutas de Alvados	4	Min.	1.645	0.836	1.968	3-toothed
				4	Max.	1.900	0.880	2.159	

Table I. Continuation.
Tabla I. Continuación.

Species	Sample no.	Region	Locality	N		Shell height	Shell breadth	height/ breadth	Teeth
				4	Mean	1.758	0.865	2.032	
				4	S.D.	0.108	0.020	0.089	
callicratis	2010.P64	Estremadura	1.5 km SE. of Livramento	37	Min.	1.550	0.804	1.832	3-toothed
				37	Max.	2.037	0.960	2.273	
				37	Mean	1.773	0.874	2.027	
				37	S.D.	0.126	0.029	0.129	
callicratis	2010.P43	Estremadura	Fórnea	39	Min.	1.458	0.824	1.697	3-toothed
				39	Max.	2.031	0.957	2.163	
				39	Mean	1.715	0.873	1.965	
				39	S.D.	0.097	0.031	0.083	
callicratis	2011.P175	Ribatejo	just W. of Tomar	22	Min.	1.602	0.837	1.839	3-toothed
				22	Max.	1.964	0.927	2.187	
				22	Mean	1.787	0.881	2.028	
				22	S.D.	0.095	0.023	0.091	
callicratis	2010.P41	Ribatejo	SE. of Moitas Venda	13	Min.	1.654	0.838	1.933	3-toothed
				13	Max.	1.942	0.935	2.152	
				13	Mean	1.790	0.886	2.021	
				13	S.D.	0.088	0.030	0.069	
callicratis	2010.P79	Beira Litoral	1km SW. of Alfarelos	5	Min.	1.493	0.772	1.885	3-toothed
				5	Max.	1.727	0.861	2.006	
				5	Mean	1.606	0.826	1.943	
				5	S.D.	0.089	0.033	0.058	
callicratis	P45	Beira Litoral	Vale da Couda	1		1.711	0.848	2.018	3-toothed
				1		1.563	0.828	1.888	3-toothed
callicratis	2010.P78	Beira Litoral	1 km NW. of Verride	24	Min.	1.623	0.840	1.868	3-toothed
				24	Max.	2.089	0.914	2.387	
				24	Mean	1.859	0.880	2.112	
				24	S.D.	0.145	0.021	0.142	
callicratis	2010.P75	Beira Litoral	2 km WNW. of Ansião (ledge on crag)	54	Min.	1.457	0.812	1.748	3-toothed
				54	Max.	1.926	0.916	2.128	
				54	Mean	1.657	0.854	1.940	
				54	S.D.	0.103	0.023	0.103	
callicratis	2010.P73d	Beira Litoral	1.5 km WNW. of Ansião	9	Min.	1.696	0.850	1.899	3-toothed
				9	Max.	1.931	0.907	2.129	
				9	Mean	1.779	0.878	2.026	
				9	S.D.	0.066	0.019	0.068	
callicratis	2011.P170	Trás-os-Montes	NNE. of Rabal	1		2.007	0.912	2.201	toothless
				1		1.770	0.894	1.980	toothless
cylindrica	37070	Hautes-Pyrénées	8.2 km SW. from Gavernie	20	Min.	1.802	0.912	1.976	
				20	Max.	2.244	1.011	2.265	
				20	Mean	2.007	0.956	2.099	
				20	S.D.	0.104	0.023	0.080	

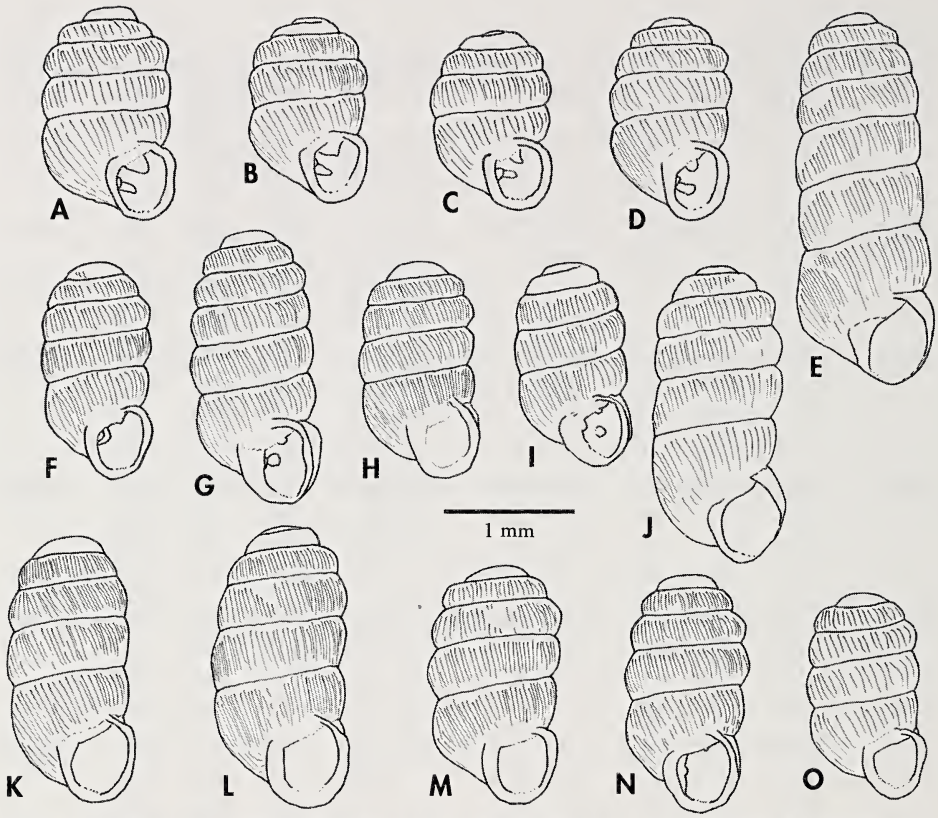

Figure 1. Drawings of representative shells of *Truncatellina* spp. A-D, *T. beckmanni*: A, Ribatejo, Portugal (site P41), B, Menorca (topotype, no. 11296), C, D, Beira Litoral, Portugal (site P46); E, *T.* cf. *callicratis*: Prov. Girona, Spain (no. 1983.147.20a); F-I, *T. callicratis*: F, G, Estremadura, Portugal (site P64, small and large shells from same population), H, Algarve, Portugal (site P118), I, Algeria (no. 1984.267.1); J, *T.* cf. *callicratis*: Prov. Girona, Spain (no. 1983.147.20a); K, L, *T. cylindrica*: K, Bedfordshire, England (no. 1977.140.1), L, Hautes-Pyrénées, France (collected 2001.06.28); M-O, *T. callicratis*: M, Morocco (no. 1986.311.04), N, Dorset, Great Britain (no. 1977.150.1), O, Morocco (no. 1986.80.4, from population with widely spaced ribs on shells). Note that shells G, I and N have been rotated slightly to show columellar tooth; other shells were drawn with aperture facing upwards. E, I and J had lost the periostracum, so the suture appears rather shallow; the other specimens had the periostracum ± intact. E and J are "overgrown" shells lacking thickened mature peristome, E with shallow suture, J with deep suture on part of shell. See Appendix for details of specimens figured.
Figura 1. Dibujos de conchas representativas de Truncatellina *spp. A-D,* T. beckmanni*: A, Ribatejo, Portugal (localidad P41), B, Menorca (topotipo, nº 11296), C, D, Beira Litoral, Portugal (localidad P46); E,* T. *cf.* callicratis: *Prov. Girona, España (nº 1983.147.20a); F-I,* T. callicratis: *F, G, Estremadura, Portugal (localidad P64, conchas pequeñas y grandes de la misma población), H, Algarve, Portugal (localidad P118), I, Argelia (nº 1984.267.1); J,* T. *cf.* callicratis: *Prov. Girona, España (nº 1983.147.20a); K, L,* T. cylindrica: *K, Bedfordshire, Inglaterra (nº 1977.140.1), L, Hautes-Pyrénées, Francia (recolectadas 28.06.2001); M-O,* T. callicratis: *M, Marruecos (nº 1986.311.04), N, Dorset, Gran Bretaña (nº 1977.1501.1), O, Marruecos (nº 1986.80.4, de una población con conchas con costillas muy separadas). Nótese que las conchas G, I y N se han girado ligeramente para mostrar el diente columelar; otras conchas han sido ilustradas mostrando la abertura hacia arriba. E, I y J han perdido el periostraco, por lo que la sutura parece bastante superficial; los otros ejemplares tenían el periostraco ± intacto. E y J son conchas de crecimiento anómalo faltándoles el peristoma típico de ejemplares maduros, E con sutura poco profunda, J con sutura profunda en parte de la concha. Ver apéndice para los detalles de los ejemplares figurados.*

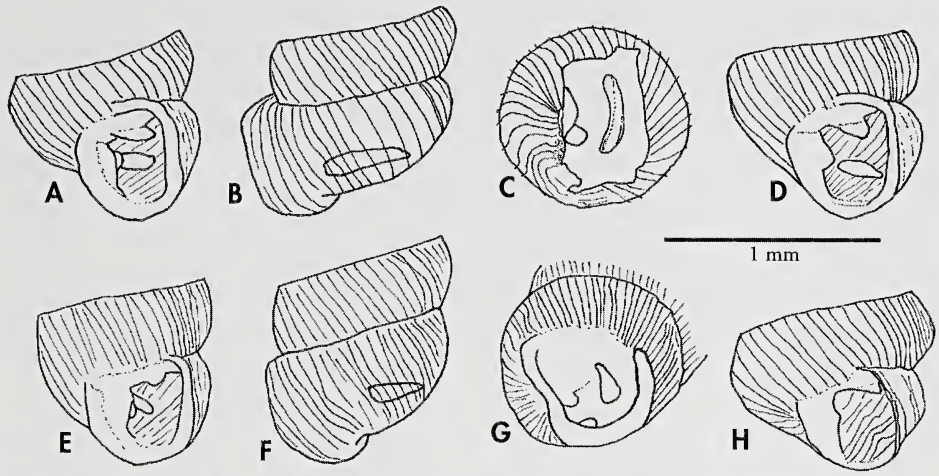

Figure 2. Drawings of apertural teeth of *Truncatellina* spp. A-D, H, *T. beckmanni* from Ribatejo, Portugal (site P41), E-G, *T. callicratis* from Estremadura, Portugal (site P64). A, D, E and H, show shell aperture facing approximately upwards, but rotated slightly to reveal columellar tooth; B and F, show back of body whorl with aperture facing downwards, the opaque white base of the palatal tooth being outlined; C, is view from below of an adult shell from which the peristome and palatal part of the aperture have been broken away to reveal the columellar tooth (left of centre) and full length of parietal tooth (right of centre), mouth of the aperture being at top of drawing; G, as C except that view is somewhat oblique, revealing full length of parietal tooth and top of palatal tooth; H, subadult shell with three small teeth, but peristome not thickened or reflected. See Appendix for details of specimens figured.

Figura 2. Dibujos de dientes aperturales de Truncatellina *spp. A-D, H,* T. beckmanni *de Ribatejo, Portugal (localidad P41), E-G,* T. callicratis *de Estremadura, Portugal (localidad P64). A, D, E y H, muestran la abertura de la concha orientada aproximadamente hacia arriba, pero ligeramente giradas para mostrar el diente columelar; B y F, muestran la parte posterior de la vuelta principal con la abertura orientada hacia abajo, la base blanca opaca del diente palatal se ha resaltado; C, concha adulta vista desde abajo en la que el peristoma y la parte columelar de la abertura se han roto para mostrar el diente columelar (a la derecha del centro), estando la boca de la abertura situada en la parte superior del dibujo; G, como C aunque esta vista es algo oblicua, revelando la longitud total del diente parietal y la parte superior del diente palatal; H, concha subadulta con tres dientes pequeños, aunque el peristoma no está engrosado ni reflejado. Ver apéndice para los detalles de los ejemplares figurados.*

Libya) and *T. purpuraria* Hutterer & Groh, 1991 (described from undated fossil or subfossil shells from Lanzarote, Alegranza and Fuerteventura in the eastern Canary Islands). *T. klemmi* differs from *T. beckmanni* in its wider shell (height 1.4-1.8 mm, breadth 1.0-1.2 mm) although our Portuguese sample with broadest shells (0.869-1.008, mean 0.928 mm: Table I) may nevertheless show slight overlap. The ribs on shells of *T. klemmi* are rather widely and regularly spaced as in *T. beckmanni*, but with broader, higher crests forming low lamellae.

Compared to our specimens of *T. beckmanni* from Portugal and Andalucia, *T. purpuraria* differs in having much more closely spaced ribbing on the shell and a rounded palatal tooth, whereas in *T. beckmanni* the palatal tooth is much longer than wide, forming a low lamellar rib extending back into the aperture (Fig. 2B). See above for comments on development of a parietal callus in *T. beckmanni*.

T. purpuraria was described as showing the closest relationship in conchological characters to Ethiopian species of the genus (*T. lardea* (Jickeli, 1875), *T.*

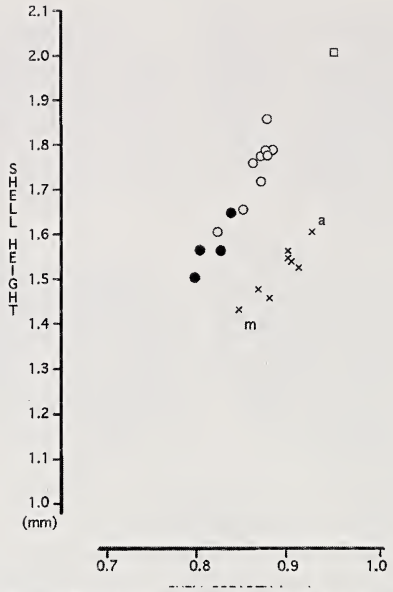

Figure 3. Graph of mean shell height and mean shell breadth for population samples of *Truncatellina* spp. ×= *T. beckmanni* from Portugal, a= *T. beckmanni* from Andalucia, m= *T. beckmanni* from Menorca (data from QUINTANA, 2010), ○= *T. callicratis* from C. Portugal (populations with three apertural teeth), ●= *T. callicratis* from S. Portugal (populations mainly or entirely lacking apertural teeth), ❑= *T. cylindrica* from French Pyrenees.

Figura 3. Gráfico de la altura media y anchura media de la concha para las muestras de poblaciones de Truncatellina *spp.* ×= T. beckmanni *de Portugal, a*= T. beckmanni *de Andalucía, m*= T. beckmanni *de Menorca (datos de QUINTANA, 2010),* ○= T. callicratis *de C. Portugal (poblaciones con tres dientes aperturales),* ●= T. callicratis *de S. Portugal (poblaciones casi o completamente desprovistas de dientes),* ❑= T. cylindrica *de los Pirineos franceses.*

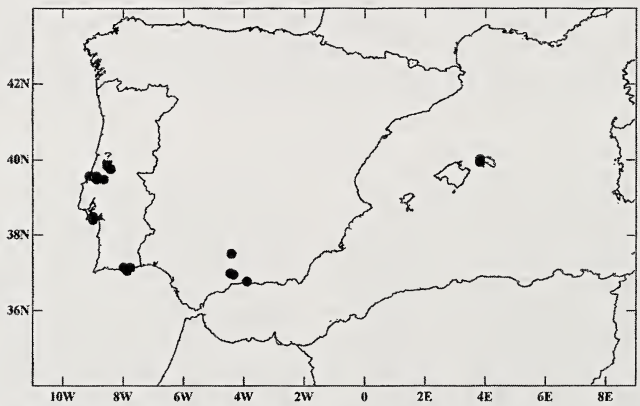

Figure 4. Map of distribution of *Truncatellina beckmanni*, based on specimens examined (except for some of the data from Menorca, from QUINTANA, 2010). ?= identification not certain because good adult shells not seen.

Figura 4. Mapa de distribución de Truncatellina beckmanni, *basado en los ejemplares examinados (excepto para algunos, recavados de los datos de Menorca, de QUINTANA, 2010). ?= identificación dudosa por no haber podido ver buenos ejemplares adultos.*

schilleri (Jickeli, 1875), *T. similis* (Jickeli, 1875)), and the same may apply to *T. klemmi* and *T. beckmanni*, if the similarities are not merely results of convergent evolution of shell characters. Of these species, *T. schilleri* and *T. similis* differ from *T. purpuraria* in having "palatal folds (not teeth!) ... only visible in an oblique view in the aperture, furthermore both are narrowly umbilicated". "*T. lardea* resembles *T. purpuraria* at first sight but is slightly larger ..., its palatal tooth is more elongated and – most striking – the costulation is much sparser" (HUTTERER AND GROH, 1991). *T. klemmi* was said to differ from *T. purpuraria* in being significantly wider (1.0-1.2 mm), sparsely but prominently costulated, with its crest-like teeth placed more deeply in the aperture (HUTTERER AND GROH, 1991: 8).

The habitats from which we have collected *T. beckmanni* are at 10-840 m elevation, mainly on limestone slopes with rock exposed more or less extensively as crags or screes. The sites mostly have open or incomplete vegetation cover, of herbs, grasses, or bushes. One atypical record was from crevices of walls alongside a river (Río Chillar, Nerja, Prov. Málaga). A second atypical record was of a single shell from a low, isolated, granite hill with crags and rather open low woodland (São Bartolomeu, 2 km SE. of Nazaré, Estremadura), a locality with some base in the soils because of calcareous sand blown in from surrounding low ground. *T. callicratis* was usually present with *T. beckmanni*, or close by, including at both of the atypical sites mentioned.

Truncatellina callicratis (Scacchi, 1833)

Turbo callicratis Scacchi, 1833, Osserv. Zool., p. 11. Type locality: Naples, Botanical Garden [Italy]. Types: unknown.

syn. *Pupa rivierana* Benson, 1854, Ann. Mag. Nat. Hist., (2), 13, p. 97. Type locality: Riviera regione Pedemontana, ad basin collium prope Nizza maritimam sub lapide [Italy].

Pupa strobeli Gredler, 1856, Verh. Zool.-bot. Vereins in Wien, 6, p. 114. Type locality: Klausen, southern Tyrol, on the garden hill of the Capuchin Fathers [Austria].

Vertigo muscorum var. *triplicata* Bourguignat, 1864, Malac. de l'Algérie, 2, p. 99, pl. 6, figs. 31-32. Type locality: Algérie, près de Bône, dans les alluvions de le Boudjimah, et dans celles de l'Harrach, près de Alger.

P.[*upa*] (*Isthmia*) *Scharffi* O. Boettger, 1879, Nachrbl. dtsch. Mal. Ges., 11 (No. 4-5, April-Mai), p. 51. Type locality: Genist ... am Ufer der Garonne [Bordeaux, France].

Pupa Strobeli var. *Scharffi* O. Boettger: anon., 1879 [October, or later], J. Conch., Lond., 2, p. 291. From "alluvium at Bordeaux".

Pupa strobeli var. *callicratis* Sc.: Westerlund, 1887, Fauna pal. Reg. Binnenconch., 3, p. 126.

Isthmia doumeti Letourneux and Bourguignat, 1887, Prodr. Malac. Tunisie, p. 110. Type locality: Tunis: drift debris of the Oued Sidi-Aich.

Isthmia rothi Reinhardt, 1916, Nachrbl. dtsch. Mal. Ges., 48, p. 164. Type locality: Greece, around Athens.

Truncatellina rivierana britannica Pilsbry, 1921, Man. Conch., 26, p. 77, pl. 8, figs. 13, 14. Type locality: Portland, Dorset, England. Holotype and paratypes at ANSP (not seen).

Truncatellina britannica Kennard and Woodward, 1923, Proc. Malac. Soc. Lond., 15 (6), p. 294.

Truncatellina brandti Zilch, 1962, Arch. Moll., 89 (1-3) [for 1960], 58, pl. 9, fig. 2. Type locality: Wadi Halgh el Asel zwischen Tokra und Tolmetta [Cyrenaica, Libya]. Holotype and paratypes at SMF.

Truncatellina lussinensis Štamol, 1995, Arch. Moll., 124 (1/2), p. 99, figs. 3, 4, 7, 8. Type locality: Croatia, the island of Lošinj, Veli Lošinj. Holotype no. 4993 and two paratypes no. 4994: Croatian Natural History Museum, Zagreb (not seen).

PILSBRY (1921) adopted the name *T. rivierana* for the species. However, he cited information from WESTERLUND (1887: 126) who obtained specimens from the original locality of *callicratis*, stated that it is a form of *strobeli* and accorded it varietal rank under that species (see above). Recent authors have

therefore used *callicratis* as the species name because it has priority.

Diagnostic characters: Apertural teeth 0-3 in mature shells, most populations being comprised mainly of shells with 0 or 3 teeth. When a palatal tooth is present it is visible with at least an oblique view into shell mouth; when a parietal tooth is present it is relatively small, not forming a tall lamellar ridge. Shell short to long (height 1.26-2.09 mm), usually relatively narrow (height/breadth 1.6-2.3; shell breadth 0.76-0.96 mm, population means 0.80-0.89 mm); ribs on body whorl usually closely spaced. The whorl profile tends to be higher and more rounded than in *T. cylindrica*.

Data on occurrence of apertural teeth in samples of this species are presented in Table II for the larger samples (>7 shells). Figure 5 shows the geographical pattern of occurrence of toothed, untoothed and partly toothed populations. However, Fig. 5 does not show populations which were not confidently identified as *T. callicratis*. The material excluded in this way from Fig. 5 mostly comprises small samples of shells lacking teeth, often old shells lacking the periostracum. These are likely to consist mainly of toothless *T. callicratis* with shells that do not clearly show deep sutures and a rounded whorl profile, probably because of the poor condition of the shells.

From Fig. 5 and Table II it is clear that untoothed populations predominate in the southernmost parts of the range, especially at low elevations in Morocco. Toothed and partly toothed populations are commoner in N. Algeria. Southern Iberia (Algarve and Andalucia) has untoothed populations or toothed populations with fewer than three teeth, whereas central and northern Iberia and France show mainly or entirely three-toothed (111) populations. Nevertheless, the northernmost population studied at Portland, Dorset, England has only a minority of 111 shells, accompanied by various types having one or two teeth, as pointed out long ago by Kennard and Woodward (1923) and confirmed by our data (Table II).

The literature as a whole has evidently treated *Truncatellina* lacking apertural teeth or with few weak teeth from S. Iberia and NW. Africa as belonging to *T. cylindrica* rather than *T. callicratis* (Bourguignat, 1864; Hidalgo, 1875, 1874; Pilsbry, 1920-1921; Nobre, 1941: 152-153; Martínez-Ortí and Robles, 2003; Ruiz *et al.*, 2006). This may be due partly to copying from the oldest literature which regarded *T. cylindrica* as the only species in its (sub) genus, an unsurprising assumption in the early years when most studies were carried out without adequate microscopes. That treatment was also maintained by some later workers adhering to an extraordinarily broad species concept, notably Nobre (1941).

Our own efforts to find *T. cylindrica* among numerous samples of untoothed *Truncatellina* from S. Iberia and NW. Africa have consistently been unsuccessful. Topotypical *T. cylindrica* from France differ from untoothed *T. callicratis* in characters set out in the diagnosis above and key below, principally larger size, shallower sutures and a flatter whorl profile (Table 1, Figs. 1, 3). Close comparisons of large samples of three-toothed *T. callicratis* from central Portugal (Beira Litoral, Ribatejo, Estremadura) with untoothed or predominantly untoothed populations in the Algarve shows that the latter actually average considerably smaller in size (Fig. 3, Table I) while sharing the deep sutures and rounded whorl profile characteristic of toothed *T. callicratis*. Furthermore, prolonged study of "apparently toothless" populations reveals that some include a proportion of weakly toothed shells, most often with just a columellar tooth present (e.g. P104 at Rocha da Pena in the Algarve; several Moroccan samples, notably 1986.326.1, 1984.153.4, 1984.139.1; a majority of the larger samples from N. Algeria) (Table II).

Recognition that populations of *T. callicratis* commonly show reduced or absent apertural teeth prompts reassessment of several nominal taxa listed as synonyms above.

The reduced teeth of British shells led Pilsbry (1921) to name them as *T. rivierana britannica*, and Kennard and

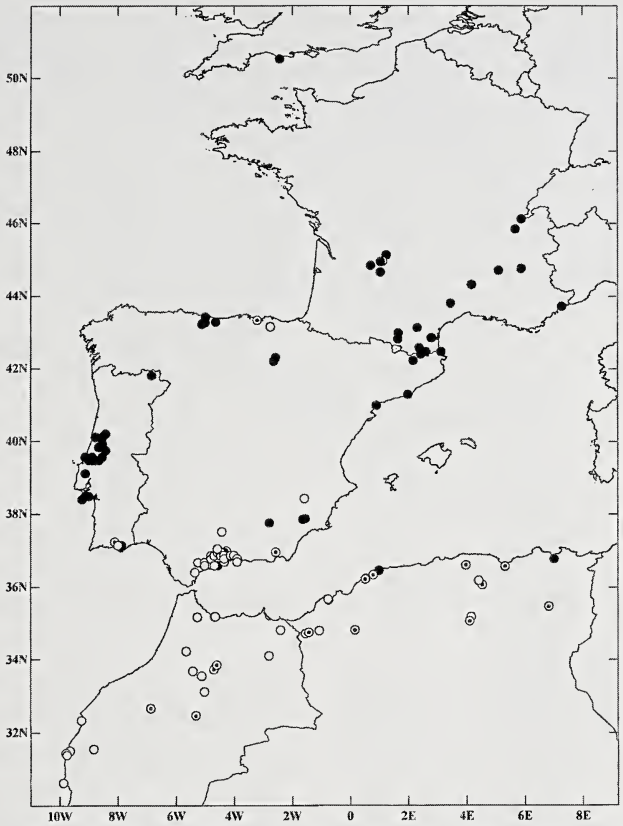

Figure 5. Map of distribution of *Truncatellina callicratis* based on specimens examined. ●= >80 per cent of shells with one or more apertural teeth; ○= no shells with apertural teeth; circles with central dot= 1-80 per cent of shells with apertural tooth or teeth, remainder lacking teeth.
Figura 5. Mapa de distribución de Truncatellina callicratis *basado en los ejemplares examinados.* ●= *>80 por ciento de las conchas con uno o más dientes aperturales;* ○= *conchas sin dientes aperturales; círculos con punto central= 1-80 por ciento de conchas con un diente o más, el resto sin dientes.*

WOODWARD (1923: 296) thought that other differences may exist to justify separation of *T. britannica* at species rank. Nevertheless, they admit to doubt over whether it is a variety, subspecies or distinct species, which they "have not yet had the opportunity of determining". Subsequent studies have failed to reveal other differences between British and continental material and the reduced apertural teeth now seem unimportant when the whole pattern of variability in occurrence of apertural teeth in *T. callicratis* is considered. Because a sample of British shells with reduced teeth can be matched by various samples from Iberia any nomenclatural recognition seems unwarranted.

PILSBRY (1921: 72) gave a muddled citation of "*Pupa strobeli* var. *scharffi* Boettger, Nachrbl. d. Mal. Ges., 1879, p. 51". In fact, at the reference given, O. BOETTGER (1879: 51) named *P.*[*upa*] (*Isthmia*) *Scharffi* based on three shells collected from river debris at Bordeaux by Robert Scharff. Later in the same year, Mr Scharff exhibited specimens at a meeting of the Conchological Society in Bradford, the account of which (ANON., 1879) gives the name as *Pupa Strobeli* var. *Scharffi*, "described by Dr. Boettger of Frankfort". T. von Proschwitz (in FALKNER *ET AL.*, 2002:

Table II. Data on occurrence of apertural teeth in samples of *Truncatellina callicratis*. Data are listed here for samples of >7 shells; *= shells from floodline debris. See text for methods used in scoring shells. A shorthand notation was used in scoring teeth of individual shells, taking the names in alphabetical order as columellar, palatal, parietal; thus *e.g.*, 111= all three teeth present, 000= no teeth present, 101= columellar and parietal present but not palatal.

Tabla II. Datos sobre la presencia de dientes aperturales en muestras de Truncatellina callicratis. *Se listan los datos de las muestras de >7 conchas; *= conchas de sedimentos de ríos. Ver el texto para los métodos usados para contabilizar las conchas. Una anotación taquigráfica se usó para contar los dientes de las distintas conchas, ordenando los nombres alfabéticamente como columelar, palatal, parietal; así p. ej., 111= los tres dientes presentes, 000= ningún diente presente, 101= columelar y parietal presentes, aunque no el palatal.*

Country, Province	Site no., Specimen no. or date	Teeth: 000	100	010	001	110	011	101	111	Total
Great Britain, Dorset	1976.194.1, 1977.150.1, 1982.138.1	–	4	–	–	1	–	2	2	9
Great Britain, Dorset	from Kennard and Woodward (1923)	2	77	–	–	26	–	–	5	110
France, Ain	1976.228.7a, 1976.228.23	2	–	1	–	4	1	–	11	19
France, Ain	1987.2.1, 1987.2.2	2	–	–	–	–	–	–	30	32
France, Dordogne	1981.13b.7	–	–	–	–	3	1	–	9	13
France, Dordogne	1981.14b.2, 1981.14b.5	4	–	–	–	1	1	2	7	15
France, Drôme	1985.368.1	–	–	–	–	–	2	1	13	16
France, Ariège	1981.55.1	–	–	–	–	5	–	–	4	9
France, Pyrénées-Orientales	1981.58.2	–	–	–	–	–	–	–	16	16
France, Pyrénées-Orientales	1981.67.4	–	–	–	–	10	–	–	43	53
France, Pyrénées-Orientales	1981.73.1	–	–	1	–	3	–	–	8	12
N. Spain, Asturias	E159	1	–	–	1	–	3	–	36	41
N. Spain, Cantabria	2001.05.22	–	–	–	–	–	1	–	11	12
N. Spain, Girona	2001.06.16	–	–	1	–	13	4	–	89	107
*N. Spain, Girona	1983.147.20, 1983.147.21	36	–	–	–	–	–	–	20	56
N. Spain, Tarragona	1984.65.1	2	4	–	–	4	–	5	16	31
C. Portugal, Beira Litoral	P75	–	–	–	–	–	–	–	46	46
C. Portugal, Beira Litoral	P78	–	–	–	–	–	–	–	20	20
C. Portugal, Beira Litoral	NE4849	–	–	–	–	–	–	–	23	23
C. Portugal, Beira Litoral	NE5051	–	–	–	–	–	–	–	19	19
C. Portugal, Beira Litoral	NE3218	1	–	–	–	–	–	–	8	9
C. Portugal, Ribatejo	P41	–	–	–	–	–	–	–	9	9
C. Portugal, Ribatejo	P175	–	–	–	–	–	–	–	15	15
C. Portugal, Estremadura	P64	2	–	–	–	–	–	–	28	30
C. Portugal, Estremadura	P43	–	–	–	–	–	–	–	36	36
S. Portugal, Algarve	P104	14	8	–	–	–	–	–	–	22
S. Portugal, Algarve	P118	59	–	–	–	–	–	–	–	59
S. Portugal, Algarve	P117	8	–	–	–	–	–	–	–	8
Malta, Gozo	2005.03.17	–	–	1	–	2	1	–	30	34
Malta, Malta	2005.03.18	1	–	–	–	–	1	–	13	15
Algeria	1984.175.2	6	–	–	–	–	–	2	–	8
Algeria	1984.176.2	11	3	–	–	–	–	2	–	16
Algeria	1984.256.2	19	4	–	–	–	–	–	–	23

Table II. Continuation.
Tabla II. Continuación.

Country, Province	Site no., Specimen no. or date	Teeth: 000	100	010	001	110	011	101	111	Total
Algeria	1984.267.1	1	–	–	–	–	–	–	10	11
Algeria	1984.293.2	11	3	–	–	–	–	3	–	17
Algeria	1984.307.1	21	3	–	1	–	–	–	–	25
Algeria	1984.316.1	15	2	–	–	–	–	2	–	19
Algeria	1984.338.4	79	14	–	–	–	–	–	1	94
Algeria	1984.357.2	24	11	–	–	–	–	1	–	36
Algeria	1984.358.1	12	9	–	–	–	–	–	–	21
Algeria	1984.367.3	38	3	–	–	–	–	–	–	41
Morocco	1984.139.1	55	12	–	–	–	–	1	–	68
Morocco	1984.153.4	40	6	–	–	–	–	1	–	47
Morocco	1986.156.6	24	1	–	–	–	–	–	–	25
Morocco	1986.162.08	14	–	–	–	–	–	–	–	14
Morocco	1986.164.01	26	–	–	–	–	–	–	–	26
Morocco	1986.326.1	23	2	–	–	–	–	–	–	25

11) described additional records of this taxon in SW. France along with intermediates linking it to typical *T. callicratis*.

There is nothing in the description of *Isthmia doumeti* Letourneux and Bourguignat, 1887 from Tunisia to show that it is anything other than the toothless form of *T. callicratis* that predominates further west in north Africa over large areas of Morocco and Algeria, so it is regarded as a synonym of the latter name. HUTTERER AND GROH (1991: 19) listed shells from Oued Chair in Algeria (SMF) that were named as *T. doumeti* and, as noted above, that taxon was also reported from near Barcelona ("Altimira, 1969", cited by BECH, 1990); both of these are also likely to be referable to toothless forms of *T. callicratis*.

Isthmia rothi Reinhardt, 1916 from Greece was said to differ from *T. cylindrica* "by the compact structure, the peculiar form, wider above, the sharp, widely spaced striation, more convex whorls and deeper suture" (PILSBRY, 1921: 70). This taxon also seems likely to be based on a toothless form of *T. callicratis*. IRIKOV (2008) reported *T. rothi* new for Bulgaria, describing and figuring toothless shells (height 1.2-1.9 mm, diameter 0.8-0.9 mm) that are a good match for toothless *T. callicratis*, with rounded whorls and a deep suture.

Truncatellina brandti was described from more than 38 shells from several localities in Cyrenaica. Its shells lack teeth and measure 1.4-1.7 mm high and 0.8 mm wide. Although showing rather strong and widely spaced ribbing, this can be matched in our Algerian material assigned to untoothed forms of *T. callicratis* and they are closely similar in the deep sutures and rounded whorl profiles.

Truncatellina lussinensis Štamol, 1995 was described from a total of 12 shells found within an area about 500 m across. The twelve specimens are large (1.95-2.75 mm high, 0.79-1.00 mm in breadth), but "unfortunately there was only one satisfactory adult specimen among all twelve specimens" (ŠTAMOL, 1995: 100). The published drawings and photographs show that the whorl profiles and ribbing of the long shells are generally similar to those of *T. callicratis*. The author refers to the phenomenon of abnormalities in the shells of Pupoidea including *Truncatellina cylindrica* as described by GEYER (1912), including larger overall size, a larger number of whorls

and an incomplete (i.e. unreflected, unthickened) edge to the aperture. He commented as follows on the "possibility of regarding *T. lussinensis* as a form of gigantism in *T. callicratis*. [and that] The suggestion could be supported by the fact that *T. lussinensis* is invariably found in small numbers together with numerous typical specimens of *T. callicratis*. However, the specimen with a complete apertural edge refutes this suspicion, as does the appearance of *T. lussinensis* on a relatively large number of sites within the Veli Lošinj area". All the specimens described by Štamol were from the collection of France Velkovrh housed in the museum at Zagreb and no information is available on whether the collector made special efforts to seek out the large shells.

The present study found that "overgrown" abnormalities may recur repeatedly within populations of *T. callicratis* (e.g. 5 shells accompanying a total of 36 normal untoothed adults in 1983.147.20a from floodline debris in Prov. Girona; Figs. 1E, J). They resemble normal shells in depth of the suture, the whorl profile and ribbing, but have extra whorls and an unthickened peristome lip, as if shell growth has continued for longer than normal. Despite the occurrence of a "complete apertural edge" in one of the twelve specimens of *T. lussinensis*, it seems safe to regard the taxon as based on "overgrown" *T. callicratis* from its population known to be present in the same area.

In S. France and Iberia we have found *T. callicratis* at 10-1130 m elevation, mainly at sites with exposed limestone [including "marble", "dolomite" or "travertine"], such as on or about crags, on rocky slopes or on screes, but our search efforts tended to be focused on these habitats. Fewer records were from ruins and old limestone walls (2), a grassy roadside bank with no rocks (1), beside small irrigation channels in an area of slaty rock (1), sandstone rocks (2), calcareous sandstone (1), other siliceous rock (1) and a low granitic hill in an area receiving wind-blown calcareous sand (1). Its sites usually had incomplete or rather open cover of vegetation, typically of herbs, grasses or patchy bushes, but a few records were in places shaded by scrub or inside woodland.

Collections from Morocco and Algeria were made from 20-2200 m elevation, ranging from sites on sea-cliffs up to altitudes of 1760 and 2200 in the Moyen Atlas. Rocky limestone habitats predominated (21 sites), with other rocky sites recorded over varied sedimentary lithologies (calcareous sandstone (6), sandstone (3), shale (2), conglomerate (1)). The minority of sites with few or no rocks included a roadside bank (1) and a wooded hillside (1) both in a sandstone region, sandy sea-cliffs (1), calcareous clay slopes (1), sand dunes with some limestone boulders (1) and flat soil in a limestone region (1). Most of the localities had open vegetation, with a few inside open woodland or scrub.

Truncatellina cylindrica (A. Férussac, 1821)

Vertigo cylindrica A. Férussac, 1821, Tabl. Syst., p. 64. Type locality: France. Based on *Pupa muscorum, a* of Draparnaud, 1806, Hist. Nat. Moll. terr. et fluv. de France, p. 59, pl. 3, figs, 26, 27 in part (non Linnaeus), but with qualification added by Férussac of "bouche sans dents".

syn. *Truncatellina arcyensis* Klemm, 1943, Arch. Moll., 75 (2/3), p. 100. Type locality: Département Yonne, N. Avallon, S. end of road tunnel near Arcy sur Cure [France]. Holotype in Naturhistorisches Museum, Wien (Austria), collection Klemm 8378 (not seen).

Diagnostic characters: Apertural teeth always lacking. Compared to forms of *T. callicratis* lacking apertural teeth, shells relatively large (height 1.80-2.24 mm), shells usually wider (breadth 0.91-1.01 mm), sutures relatively shallow, whorl profile lower and somewhat flatter.

The discussion of *T. callicratis* above points out that it has often been reported erroneously as *T. cylindrica* in the

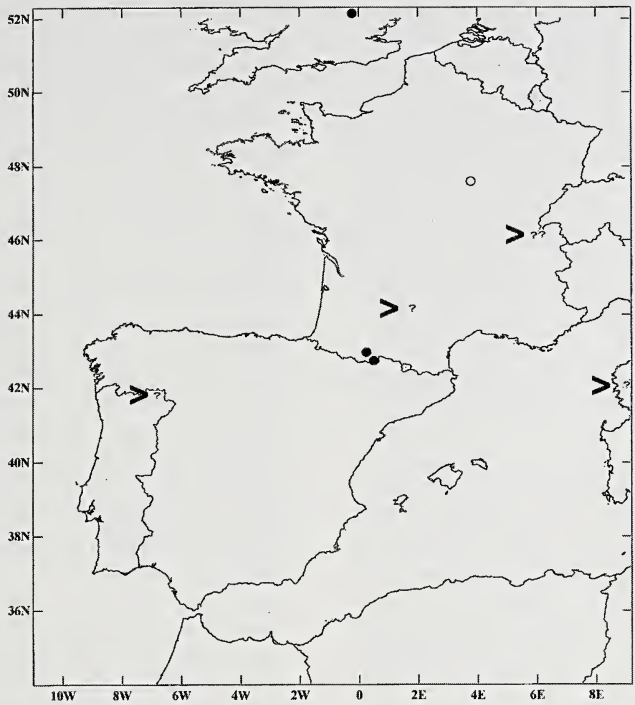

Figure 6. Distribution map of *Truncatellina cylindrica* based on specimens examined. ●= typical *T. cylindrica*; O= shells showing characters of *T. arcyensis* (see text); ?= identification not certain.
Figura 6. Mapa de distribución de Truncatellina cylindrica *basado en los ejemplares examinados.* ●= T. cylindrica *típicos;* O= *conchas que muestran caracteres de* T. arcyensis *(ver texto); ?= identificación dudosa.*

past from Iberia and NW. Africa. In the present study, the southernmost records of material confidently identified as *T. cylindrica* were from the French side of the Pyrenees, with only tentative records based on very few shells from further south at single localities in Corsica and NE. Portugal (Fig. 6, Appendix).

RUIZ *ET AL.* (2006: 242-243) mapped *T. cylindrica* as having a range in Andalucia more widespread than that of *T. callicratis*. However, the short description of *T. cylindrica* stated "sin dientes aperturales, aunque puede aparecer algún pliegue rudimentario" which suggests misidentification of weakly toothed *T. callicratis*, since *T. cylindrica* at its north- and central European localities always lacks teeth. Furthermore, their photos show a shell that may have carried on growing without forming a peristome lip (cf. the discussion of *T. lussinensis* above); it has deeper sutures and more swollen whorls than in *T. cylindrica*.

T. arcyensis Klemm, 1943 is known mainly from three localities in Dept. Yonne, France, with a single shell reported from river deposits in Switzerland (HAUSSER, 2005). Although treated as a valid species by recent authors (KERNEY AND CAMERON, 1979; FALKNER *ET AL.*, 2002; GARGOMINY AND RIPKEN, 2011) it resembles *T. cylindrica* rather closely in all characters other than a supposedly higher shell (2.2-2.4 mm, cf. 1.8-2.0 mm in *T. cylindrica*: KLEMM, 1943; KERNEY AND CAMERON, 1979; HAUSSER, 2005) and lack of ribs on the shell. However, a

topotype of *T. arcyensis* figured by Gargominy and Ripken (2011: Pl. 13D) clearly shows weak ribbing with similar spacing and orientation to that in *T. cylindrica*, and the mature shell involved is apparently only *ca* 1.76 mm high (little larger than the *T. cylindrica* figured in Pl. 13C of the same publication, which was collected at Mailly-le-Château in Dept. Yonne). A sample of 26 shells from Nailly Saint-Moré in Dept. Yonne collected in 1983 (NMW.Z. 1993.052.09392) is intermediate between *T. cylindrica* and the supposed characters of *T. arcyensis*. Their shell heights of 1.708-2.062 mm are well within the range of *T. cylindrica* (cf. heights up to 2.244 mm from a population with mean height of 2.007 mm (n= 20) measured during the present study: Table I) and shell breadth is also similar to that of *T. cylindrica*. Ribbing was present on all of the 26 shells, but markedly weaker (lower) than usual in *T. cylindrica;* this ribbing was almost lacking on parts of the body whorl of some fresh shells but present over all of the body whorl on others. *T. arcyensis* is therefore regarded as a weakly ribbed local form of *T. cylindrica* and placed as a synonym of that species here, although subspecific status might be justifiable. The clear differences between these taxa in shell height and ornamentation described in the literature apparently do not exist: even some topotypical *arcyensis* differ from *T. cylindrica* only in having weaker ribbing, and localities elsewhere in Dept. Yonne have more obviously intermediate shells, or typical *T. cylindrica*.

As noted above, the nearest records to the Iberian Peninsula accepted for *T. cylindrica* in this study are from the French Pyrenees. These were at elevations of 900 m and 1975 m, on rocky limestone slopes with open vegetation of grasses and herbs. It seems quite likely that the species will eventually be confirmed as occurring at least in northern Spain, most likely perhaps in montane habitats, but our study emphasises that great care will be needed to distinguish *T. cylindrica* from untoothed forms of *T. callicratis*. Further north in Europe, *T. cylindrica* occurs widely in very dry calcareous grassy places, characteristically among *Sedum* or *Artemisia*, often on screes, among rocks, or occasionally on sand dunes (Kerney and Cameron, 1979). Numerous specimens we have studied from Potton, Bedfordshire, England were from a dry sandy south-facing bank with cover of short herbaceous vegetation, but it no longer occurs there. In Poland it is commoner and occurs also in habitats of anthropogenic origin, in pastures, on railway embankments and on balks [banks] (Pokryszko, 1990: 224). In Asia and eastern Europe it occurs in steppe and semi-desert areas (Shileyko, 1984).

DISCUSSION

The apertural teeth of the *Truncatellina* species occurring in SW Europe and NW Africa are developed only as the growing shell approaches or reaches full size; small juvenile shells invariably lack teeth. In *T. beckmanni* all three teeth begin to grow before the peristome lip is thickened or reflected (Fig. 2H), whereas the smaller teeth of *T. callicratis* form as the peristome matures or later. Pokryszko (1990: 146) suggested that in *Truncatellina* the palatal tooth forms later than the columellar and parietal teeth, despite it being more deeply situated. She illustrated this in *T. costulata* (Nilsson, 1822) (cf. her Fig. 5 on p. 141), but does not make it clear that sufficient material of any other toothed *Truncatellina* species was examined during her study of Polish Vertiginidae to confirm that it is more generally applicable. Kennard and Woodward (1923: 295) had previously come to a different conclusion with British *T. callicratis "britannica"*, arguing for a columellar, palatal, parietal, sequence of development. They comment that: "The columellar tubercle, which is the most conspicuous as a rule, appears to form first, when the shell has come to full growth. The palatal tubercle

Table III. Summary of data on occurrence of shells with only one or two apertural teeth in samples of *Truncatellina callicratis*, based on totals given in Table II. For row (a), χ^2= 104.85, 5 d.f., *P*= <0.001; for row (b), χ^2= 337.64, 5 d.f., *P*= <0.001; for row (c), χ^2= 287.91, 5 d.f., *P*= <0.001.
Tabla III. Resumen de los datos sobre la presencia de conchas con sólo uno o dos dientes aperturales en muestras de Truncatellina callicratis, *basado en los totales que se dan en la Tabla II. Para la fila (a),* χ^2*= 104,85, 5 d.f., P= <0,001; para la fila (b),* χ^2*= 337,64, 5 d.f., P= <0,001; para la fila (c),* χ^2*= 287,91, 5 d.f., P= <0,001.*

Row	Population with teeth:	Numbers of shells with:						Total
		100	010	001	110	011	101	
(a)	Mainly 111	4	4	1	45	15	8	(77)
(b)	Mainly 000	81	0	1	0	0	12	(93)
(c)	British (mainly 1 or 2 teeth)	81	0	0	27	0	2	(110)

develops next, and later the parietal (though we have seen a specimen with parietal but no palatal tubercle) completing the typical three in the old age of the snail".

Our data on occurrence of teeth in numerous populations of *T. callicratis* (Table II) apparently shed more light on sequences of tooth development. Only shells lacking one or two of the three teeth are likely to be informative and the data on these is summarised in Table III, along with results of some statistical tests. The following comments on relative frequencies of the different combinations with one or two teeth (i.e. "partly toothed combinations") assume there is no resorption of teeth after they grow, a possibility that is reconsidered below.

In the predominantly three-toothed populations [111], 110 is commonest (n= 45) of the partly toothed combinations and 001 rarest of all (n= 1), suggesting the parietal tooth is commonly the last to grow and very rarely the first to grow. Both 100 (4) and 010 (4) are equally uncommon, whereas 110 is much commoner (45), implying that simultaneous growth of columellar and palatal teeth is much commoner than either of these growing before the other. Thus the usual sequence would appear to be columellar and palatal growing simultaneously, then the parietal growing last. This is different to Pozkryszko's proposed sequence described above (i.e. columellar and parietal growing together, with palatal last) and more like Kennard and Woodward's sequence (columellar first, palatal second, parietal last) but also differing from the latter in that columellar and palatal usually grow together rather than in succession. Nevertheless, a significant proportion of shells deviate from the commonest pattern of development, as revealed by a significant number with 011 (n= 15), which either would not develop a columellar tooth, or would do so later than normal.

Shells in predominantly untoothed populations [000], have 100 as much the commonest of the partly-toothed combinations (n= 81, out of total n= 82 for all single-tooth possibilities). Thus they much more often grow a columellar tooth than any other tooth. If a second tooth is grown it is normally the parietal (n= 12 for 101) not palatal (n= 0 for 110). Developing all three teeth (111) in these populations is very rare (n= 1). Only a single shell in this group of populations is out of step with the main pattern (n= 1 for 001, i.e. the parietal is the only tooth present).

Pooling all available data for British populations (from Dorset) reveals that these, uniquely, appear to grow a columellar tooth first (n= 81 for 100); sometimes either adding a palatal as the second tooth or growing it simultaneously with the columellar (n= 27 for 110). Only rarely are all three teeth

grown (n= 7 for 111). A few shells appear to be out of step with the main trend (i.e. n= 2 for 101). These data tend to support KENNARD AND WOODWARD'S (1923) conclusion on the sequence of tooth growth (columellar grows first, palatal second, parietal last), but emphasise that finally developing all three teeth is atypical, not the usual reward for achieving "old age".

Hence characteristic overall patterns of tooth development appear to exist, albeit different in predominantly three-toothed and predominantly untoothed populations and different again in Britain. There may therefore be no need to consider resorption of teeth as a possible process affecting the number and location of teeth seen in shell specimens, although some "out of step" data could have this explanation.

It might be argued that the different sequence of tooth development in predominantly three-toothed and predominantly untoothed groups of populations may point to a more significant genetic difference between them than should occur in conspecifics. However, the considerable proportion of shells that do not conform to the commonest pattern of development (minima of 15 in three-toothed group, of 1 in untoothed group) would cast doubt on any such simple division into two groups, as would the peculiarities in development revealed among the closely studied British population.

The functional role played by apertural teeth in Pupillacea and other land snails has not been satisfactorily explained, although several plausible suggestions have been made (PILSBRY, 1948; SOLEM, 1972, 1976; SHILEYKO, 1984; POKRYSZKO, 1990), which need not be mutually exclusive. Narrowing the aperture to make attacks by predatory invertebrates more difficult was discussed by SOLEM (1972, 1976) and a more general function in strengthening the aperture is possible in various species. Differing functions for the teeth in different positions were suggested by SHILEYKO (1984): the columellar aiding action of the columellar retractor muscle so as to facilitate movements and carrying the shell; the parietal dividing the pulmonary cavity into two parts that have different functions; the palatal protecting the pallial complex against pressure from neighbouring organs; all teeth may also assist in squeezing mucus from the mantle as the snail withdraws into the shell, this mucus contributing to the epiphragm. Nevertheless, POKRYSZKO (1990: 146) pointed out that teeth tend to be reduced in some Vertiginidae and the "possible role of the knob-shaped and deeply situated palatal tooth in *Truncatellina* is completely obscure."

In attempting to understand the functional significance of apertural teeth in *Truncatellina*, it may be relevant that they only develop in fully-grown snails. The large teeth of species such as *T. beckmanni* may subserve various functions among those suggested for other Pupillacea above, such as predator avoidance, partitioning the aperture, protecting organs and helping to carry, move and orientate the shell. It is noteworthy that the large teeth of this species are consistently present and vary little in size and shape (although position of the palatal tooth may vary, cf. Figs. 2A, D). In contrast, the smaller teeth of *T. callicratis* can be developed or not and whole populations have none, as do all individuals in *T. cylindrica* and other "untoothed" species of the genus. It is therefore possible that the variability in number, position, size and developmental sequence of teeth in *T. callicratis* are a reflection of weak or non-existent selection pressures. In their small and possibly vestigial condition the teeth might be functionally unimportant, or almost so, perhaps developing only through pleiotropic action of genes controlling other more important effects.

It is convenient in constructing bipartite keys to *Truncatellina* species to make an initial separation of species with and without teeth (as in PILSBRY, 1920-1921; HUTTERER AND GROH, 1991: 13; HAUSSER, 2005) and we maintain this tradition in our own "artificial" key below. Nevertheless, development of apertural teeth in *T. callicratis* is variable both within and between populations as

described above, prompting a wider reassessment of the significance of teeth in *Truncatellina*. The great intraspecific variability in one of the species implies that presence or absence of teeth should not be regarded as decisively important in showing phylogenetic affinities within the genus. Indeed, a reliable phylogeny based on a combination of molecular-genetic and morphological studies now needs to be established and this should allow reassessment of the taxonomic value of teeth and other morphological characters among the species.

Key to identification of *Truncatellina* species in W Europe and NW Africa

This key covers all species occurring in England, W. and C. France, Spain, Portugal, Morocco and Algeria, but not all taxa from the Alps or Macaronesia. The characters used are those of adult shells with a fully formed peristome lip (reflected and somewhat thickened). Identification will be more reliable if it is based on a sample of shells from each local population.

1 - Shell with 1-3 apertural teeth 2
- Shell without apertural teeth 4

2 - Palatal tooth well developed but deeply inserted, so not visible with frontal view of shell mouth (usually visible externally as opaque whitish mark); shell narrow, breadth averaging *ca* 0.75 mm; SW. France, E. Spain . . . . . *T. claustralis*
- Palatal tooth well developed, weak or absent, visible with at least an oblique frontal view of shell mouth when present; shell usually wider, breadth 0.76-1.00 mm (population means 0.80 mm or more) 3

3 - Parietal tooth large, well developed, forming tall lamellar ridge descending into aperture (Figs. 2A, C); shell short and relatively wide (height/breadth 1.4-1.9); shell breadth 0.79-1.00 mm (population means 0.85-0.94 mm); ribs on body whorl usually widely spaced . . . . . *T. beckmanni*
- Parietal tooth medium-sized, small or absent, not forming tall lamellar ridge descending into aperture (Figs. 2E, G); shell short to long, usually relatively narrow (height/breadth 1.6-2.3); shell breadth 0.76-0.96 mm (population means 0.80-0.89 mm); ribs on body whorl usually closely spaced . . . . . *T. callicratis*

4 - Sutures relatively shallow*, whorl profile lower and somewhat flatter*; shells relatively large, height 1.80-2.24 mm; shells usually wider, breadth 0.91-1.01 mm; apertural teeth always lacking . . . . . *T. cylindrica*
- Sutures relatively deep*, whorl profile higher and more rounded*; shells small to large, height 1.26-2.09 mm; shells usually narrower, breadth 0.76-0.96 mm; small apertural teeth sometimes present in similar shells from same population . . . . . *T. callicratis*

*Note that only shells with the periostracum intact should be compared. Comparison of fresh shells with old shells that have lost the periostracum will be misleading.

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APPENDIX. LIST OF REPRESENTATIVE MATERIAL STUDIED

Most specimens are listed for the rarer species, but mainly one for each province for the commoner *T. callicratis*, except in Algeria and Morocco where there are few published records. A full list with data on habitats and altitudes is available from the authors. Data are listed in sequence for each species as country, province, locality name, latitude and longitude or U.T.M. grid reference, date, collectors' initials, collector's field number, collection where housed, registration number if any, number of shells or specimens (immature or adult), additional comments (if any). To save space, identical information on species, country and province is not repeated; a semi-colon is used only to separate each sample. Abbreviations: ÁDO= Álvaro De Oliveira, CÁDO= Collection of Álvaro De Oliveira, CGAH= Collection of G.A. and D.T. Holyoak, CJSTA= Collection of J.S. Torres Alba, DTH= D.T. Holyoak, GAH= G.A. Holyoak, JQ= J. Quintana, JSTA= J.S. Torres Alba, MH= M. Holyoak, MBS= M.B. Seddon, MPK= M.P. Kerney, NMW.Z.= Department of BioSYB, National Museum and Gallery of Wales, Cardiff, U.K., RBGW= R.B.G. Williams; sh= number of shells (ad= good adult shells, i.e. peristome with lip developed, aperture not obscured by debris, apex and peristome unbroken; br= broken shells; imm= immature shells; old= old shells; plugged= inside of aperture obscured by debris so locations of one or more teeth not seen); sp= number of specimens in alcohol; ?= species identity uncertain.

T. beckmanni: Portugal, Algarve, 5 km E. of Sta. Caterina, 29S PB11, 1984.08.22, DTH, MH & MBS 1984.408.1, NMW.Z.1993.052.10221, 3 sh (2 ad 1 br, 1 imm br); *ca* 2 km E. of Santa Barbara de Nexe, 29S 059428/410732, 2011.02.03, GAH & DTH P117, CGAH, 8 sh; *ca* 3 km NNW. of Moncarapacho (just S of A22), 29S 060695/410771, 2011.02.04, GAH & DTH P118, CGAH, 20 sh; Beira Litoral, Capela Nostra Senora Covões, 29S 05511/44073, 2008.09.01, GAH P8, CGAH, 1 sh; Vale da Couda (SE. of Almoster), 29S 05487/44103, 2010.05.29, GAH & DTH P45, CGAH, 4 sh; *ca* 1 km SW. of Ateanha village (E. of Alvorge), 29S 05498/44262, 2010.05.29, GAH & DTH P46, CGAH, 11 sh; *ca* 0.5 km S. of IC8 at *ca* 2 km WNW. of Ansião, 29S 054642/441843, 2010.09.26, GAH & DTH P73, CGAH, 12 sh; Estremadura, *ca* 5 km NE. of Portinho da Arrábida, 29S NC06, 1984.08.24, DTH, MH & MBS 1984.418.1, NMW.Z.1993.052.10329, 6 sh (3 ad); Serra da Arrábida, 29S 05000/42574, 2007.05.18, GAH 2007/16, CGAH, 1 sh; cliffs over Portinho da Arrábida, Setúbal, 29S NC05, 2009.09., JSTA 10747, CGAH, 3 sh; Fórnea (SE. of Alcaria), 29S 05170/43789, 2010.05.02, GAH & DTH P43, CGAH, 1 sh; *ca* 1.5 km SE. of Livramento, 29S 05170/43806, 2010.08.06, GAH & DTH P64, CGAH, 64 sh; S. Bartolomeu, 2 km SE. of Nazaré, 29S 04955/43825, 2011.06.04, GAH & DTH P162, CGAH, 1 sh; Ribatejo, SE. of Moitas Venda , 29S 05311/43717, 2010.05.02, GAH & DTH P41, CGAH, 93 sh; Spain, Islas Baleares, Lloc de Monges Vell, Ciutadella, Menorca, 31S EE724228, 2010.08., JQ ex Colln JSTA 11296, CGAH, 1 sh, type locality (Quintana, 2010: 154); Prov. Córdoba, 2 km NE. of Cabra, UG4 (37°30´N, 4°25´W), 1984.07.10, DTH, MH & MBS 1984.90.2, NMW.Z.1993.052.10030, 11 sh (9 ad including 7 br); Prov. Málaga, Sierra de San Jorge, Villanueva del Trabuco, 30S UF89, 2001.02, JSTA 6989, CGAH, 4 sh; by N331 *ca* 1 km NW. of Pto. de Las Pedrizas, UF3 (36°59´N, 4°27´W), 1984.07.11, DTH, MH & MBS 1984.92.1, NMW.Z. 1993.052.10048, 1 sh (ad); Sierra de San Jorge, Villanueva del Trabuco, 30S UF89, 2007.09., JSTA 6989, CÁDO, 4 sh; Río Chillar, Nerja, 30S VF2272, 2011.07., JSTA 11591, CJSTA, 7 sh.

T. beckmanni?: Portugal, Beira Litoral, Q. Lágrimas, Coimbra, 29S NE4849, 2010.05.25, ÁDO QDL/09, CÁDO, 2 sh.

T. callicratis: Algeria, by W46 *ca* 2 km SE. of Sidi Yahia, Monts de Tlemcen, 34°43'N, 1°33'W, 1984.07.22, DTH, MH & MBS 1984.175.2, NMW.Z.1993.051.00070, 27 sh (8 ad); by W54 *ca* 2 km S. of Col d'Hafir, Monts de Tlemcen, 34°45'N, 1°26'W,

1984.07.23, DTH, MH & MBS 1984.176.2, NMW.Z.1993.051.00081, 37 sh (16 ad); by W19 12 km SSW. of Oulèd Mimoun, Monts de Tlemcen, 34°48′N, 1°05′W, 1984.07.23, DTH, MH & MBS 1984.179.1, NMW.Z.1993.051.00066, 7 sh (3 ad); by N6 on S. edge of Saïda (S. of Mascara), 34°49′N, 0°09′E, 1984.07.24, DTH, MH & MBS 1984.186.3, NMW.Z.1993.051.00082, 159 sh (33 ad); by N9 *ca* 13 km N. along road from Kherrata (SE. of Bejaïa), 36°34′N, 5°19′E, 1984.08.02, DTH, MH & MBS 1984.256.2, NMW.Z.1993.051.00077, 62 sh (23 ad); by N44 *ca* 1.5 km W. of Bissy (SE. of Skikda), 36°46′N, 7°00′E, 1984.08.03, DTH, MH & MBS 1984.267.1a, NMW.Z.1993.051.00071, 28 sh (11 ad); by W172 11 km WSW. of Kais (E. of Batna), 35°28′N, 6°49′E, 1984.08.06, DTH, MH & MBS 1984.293.2, NMW.Z.1993.051.00084, 46 sh (17 ad); 1 km SE. of N46 at 4 km SW. of Bou-Saada, 35°11′N, 4°09′E, 1984.08.08, DTH, MH & MBS 1984.306.1, NMW.Z.1993.051.00080, 15 sh (4 ad); by W76 8 km S. of El-Hamel (SSW. of Bou-Saada), 35°04′N, 4°06′E, 1984.08.08, DTH, MH & MBS 1984.307.1, NMW.Z.1993.051.00073, 101 sh (25 ad); by N5 *ca* 8 km W. of El Achir (W. of Bordj-Bou-Arréridj), 36°04′N, 4°32′E, 1984.08.09, DTH, MH & MBS 1984.316.1, NMW.Z.1993.051.00068, 31 sh (19 ad); *ca* 2 km E. of N5 at 13 km NW. of Mansoura (WNW. of Bordj-Bou-Arréridj), 36°11′N, 4°25′E, 1984.08.10, DTH, MH & MBS 1984.317.1, NMW.Z.1993.051.00079, 1 sh (ad); Gorges de Beni-Amrane, by N5 6 km NW. of Lakhdaria (SE. of Alger), 36°36′N, 3°58′E, 1984.08.12, DTH, MH & MBS 1984.338.4, NMW.Z.1993.051.00085, 173 sh (>94 ad); by N11 9 km NE. of El-Marsa (WSW. of Ténès), 36°27′N, 0°59′E, 1984.08.14, DTH, MH & MBS 1984.353.1, NMW.Z.1993.051.00065, 1 sh (ad); by N11 5 km SW. of le Guelta (SW. of Ténès), 36°20′N, 0°47′E, 1984.08.14, DTH, MH & MBS 1984.354.1, NMW.Z.1993.051.00069, 14 sh (3 ad); by N11 3.5 km SW. of Khadra (NE. of Mostaganem), 36°14′N, 0°32′E, 1984.08.14, DTH, MH & MBS 1984.357.2, NMW.Z.1993.051.00083, 110 sh (36 ad); by N11 7 km SW. of Khadra (NE. of Mostaganem), 36°13′N, 0°31′E, 1984.08.14, DTH, MH & MBS 1984.358.1, NMW.Z.1993.051.00076, 49 sh (21 ad); by W91A 5 km NNW. of Misserghin (SW. of Oran), 35°39′N, 0°45′W, 1984.08.15, DTH, MH & MBS 1984.367.3, NMW.Z.1993.051.00075, 69 sh (41 ad); by W91A 7 km NW. of Misserghin (SW. of Oran), 35°40′N, 0°46′W, 1984.08.15, DTH, MH & MBS 1984.368.1, NMW.Z.1993.051.00074, 5 sh (1 ad, all old); France, Dept. Ain, 1.5 km NNE. of Pugieu (by road to Virieu-le-Grand), 45°50′N, 5°40′E, 1960.07., MPK (ex DTH 1987.2.1), NMW.Z.1993.052.12899, *ca* 430 sh (>30 ad); Dept. Alpes-Maritimes, Rimiez, N. edge of Nice, 43°43′N, 7°16′E, 1977.12.19, DTH 1977.220a.2, NMW.Z.1993.052.02929, 5 sh (2 ad); Dept. Ariège, Arabaux, 4 km NE. of Foix, 42°59′N, 1°39′E, 1980.08.29, DTH 1981.55.1, NMW.Z.1993.052.04613, 18 sh (9 ad); Dept. Aude, by D118 just N. of Rouffiac-d'Aude, DH1 (43°08′N, 2°18′E), 1984.07.04, DTH, MH & MBS 1984.53.1, NMW.Z.1993.052.09693, 1 sh (ad); Dept. Dordogne, by D48 opposite Font de Gaume, 2 km E. of Les Eyzies, 44°56′N, 1°02′E, 1980.08.21, DTH 1981 13b.7, NMW.Z.1993.052.04325, 25 sh (13 ad); Dept. Drôme, by D93 just SE. of Mirabel-et-Blacons, FK3 (44°42′N, 5°06′E), 1985.08.24, DTH & MBS 1985.368.1, NMW.Z.1993.052.12527, 27 sh (16 ad); Dept. Gard, by D904 4 km SE. of Sauvas, EK4 (44°19′N, 4°10′E), 1983.08.26, DTH & MBS 1983.157.5, NMW.Z.1993.052.08116, 1 sh (ad); Dept. Haute-Savoie, floodline on S. bank of Rhône near Pont Carnot, NE. of Valleiry, 1976.12.26, DTH 1976.229.4, NMW.Z.1993.052.01495, 1 sh (ad old); Dept. Hérault, by D25 2 km E. of St. Pierre-de-la-Fage, EJ1 (43°48′N, 3°27′E), 1983.08.25, DTH & MBS 1983.151.4, NMW.Z.1993.052.08075, 1 sh (ad); Dept. Isère, by D537 2 km NNW. of St.-Disdier, GK1 (44°45′N, 5°53′E), 1985.08.24, DTH & MBS 1985.362.1, NMW.Z.1993.052.12503, 3 sh (ad); Dept. Pyrénées-Orientales, La Preste, 42°24′N, 2°25′E, 1980.09.03, DTH 1981.67.4, NMW.Z.1993.052.04708, 103 sh (53 ad); Great Britain, Dorset, Church Ope Cove, Isle of Portland, UK grid: SY698711, 1977.04.25, RBGW (Ex DTH 1977.150.1), NMW.Z.1993.052.02531, 3 sh (ad); S. of Church Ope Cove, Portland Bill, UK grid: SY696707, 1982.06.14, DTH 1982.138.1, NMW.Z.1993.052.06965, 28 sh (3 ad); Malta, Gozo, Ghar Ilma, S. of Xewkija, 329/860,

2005.03.17, GAH, CGAH, 31 sh; Malta, Ta' Dmejrek, SE. of Dingli, 450/396, 2005.03.18, GAH, CGAH, 12 sh; Morocco, by P24 *ca* 4 km NE. of Zaouïa ech Cheïkh, 32°40'N, 6°52'W, 1984.07.18, DTH, MH & MBS 1984.139.1, NMW.Z.1993.051.00058, >400 sh (68 ad); by P21 *ca* 14 km S. of Timahdite, Moyen Atlas, 33°07'N, 5°01'W, 1984.07.19, DTH, MH & MBS 1984.147.2, NMW.Z.1993.051.00062, 6 sh (ad, old); *ca* 18 km SE. of Sefrou, Moyen Atlas, 33.73°N, 4.70°W, 1984.07.20, DTH, MH & MBS 1984.153.4, NMW.Z.1993.051.00063, >300 sh (47 ad); *ca* 6 km W. of El Menzel, Moyen Atlas, 33°51'N, 4°36'W, 1984.07.20, DTH, MH & MBS 1984.156.6, NMW.Z.1993.051.00060, 64 sh (25 ad); by S5306 *ca* 1.5 km NE. of Taforalt (SW. of Berkane), 34°49'N, 2°24'W, 1984.08.17, DTH, MH & MBS 1984.373.4, NMW.Z.1993.051.00052, 13 sh (3 ad); N. edge of Chechaouèn, 35°10'N, 5°16'W, 1984.08.19, DTH, MH & MBS 1984.386.5, NMW.Z.1993.051.00059, 11 sh (3 ad); E. bank of Oued Ouringa, 2 km SW. of El Jebha, 35°11'N, 4°41'W, 1986.06.28, DTH, MH & MBS 1986.80.4, NMW.Z.1993.051.00047, 20 sh (3 ad); by road 8500 1.5 km due SE. of El-Jebha, 35°11'N, 4°39'W, 1986.06.28, DTH, MH & MBS 1986.81.2, NMW.Z.1993.051.00061, 10 sh (3 ad); by road 5348 14 km SE. along road from Ersaf, 34°06'N, 2°49'W, 1986.06.30, DTH, MH & MBS 1986.101.1, NMW.Z.1993.051.00054, 10 sh (3 ad); by P10 9 km W. along road from Chichaoua, 31°33'N, 8°50'W, 1986.07.08, DTH, MH & MBS 1986.158.1, NMW.Z.1993.051.00050, 1 sh (ad, old); by P10, 10 km WSW. along road from Ounara, 31°30'N, 9°39'W, 1986.07.08, DTH, MH & MBS 1986.162.08 (site 118), NMW.Z.1993.051.00057, 106 sh (14 ad); *ca* 9.5 km SSW. of Essaouira, 31°26'N, 9°47'W, 1986.07.08, DTH, MH & MBS 1986.164.01 (site 120), NMW.Z.1993.051.00049, 48 sh (26 ad); *ca* 9 km NE. along road from Sidi -Kaouki (S. of Essaouira), 31°23'N, 9°45'W, 1986.07.09, DTH, MH & MBS 1986.165.01 (site 121), NMW.Z.1993.051.00048, 13 sh (6 ad); by P8, 2 km SE. of lighthouse at Cap Rhir, 30°37'N, 9°52'W, 1986.07.10, DTH, MH & MBS 1986.176.03 (site 132), NMW.Z.1993.051.00046, 6 sh (4 ad); near P21, 3 km WNW. of El-Hajeb (centre), 33°41'N, 5°25'W, 1986.07.22, DTH, MH & MBS 1986.311.04 (site 267), NMW.Z.1993.051.00055, 22 sh (7 ad); by 5121, 6 km NW. along road from Safi (centre), 32°20'N, 9°15'W, 1986.07.24, DTH, MH & MBS 1986.276.03 (site 232), NMW.Z.1993.051.00045, 1 sh (ad, old); by P3, 6 km ENE. of Sidi-Kacem, 34°14'N, 5°39'W, 1986.07.28, DTH, MH & MBS 1986.306.05 (site 262), NMW.Z.1993.051.00043, 25 sh (5 ad); by old S309, 1.5 km SE. of Zaonïa-d-'Ifrane, 33°33'N, 5°07'W, 1986.07.29, DTH, MH & MBS 1986.313.04 (site 269), NMW.Z.1993.051.00042, 7 sh (5 ad); by track 8 km W. along track from Tounfite, 32°28'N, 5°19'W, 1986.07.31, DTH, MH & MBS 1986.326.1, NMW.Z.1993.051.00044, 46 sh (25 ad); Portugal, Algarve, *ca* 3 km NNW. of Moncarapacho (just S of A22), 29S 060695/410771, 2011.02.04, GAH & DTH P118, CGAH, 59 sh; Beira Litoral, *ca* 0.5 km S. of IC8 at *ca* 2 km WNW. of Ansião, 29S 054642/441843, 2010.09.26, GAH & DTH P75, CGAH, 54 sh; Estremadura, *ca* 1.5 km SE. of Livramento, 29S 05170/43806, 2010.08.06, GAH & DTH P64, CGAH, 37 sh; Ribatejo, Convento de Cristo, just W. of Tomar, 29S 05499/43839, 2011.08.05, GAH & DTH P175, CGAH, 22 sh; Trás-os-Montes, by IP2/N103-7 *ca* 2 km NNE. of Rabal, 29T 06873/46388, 2011.06.29, GAH P170, CGAH, 2 sh; Spain, Prov. Albacete, by N301 3.5 km N. of Cancárix, XH1 (38°26´N, 1°35'W), 1984.07.09, DTH, MH & MBS 1984.78.1, NMW.Z.1993.052.09947, 1 sh (ad); Prov. Almería, El Escaramujo, Alhama de Almería, Sierra de Gádor, 36°57´N 2°34´W, 2009.05., JSTA 10662, CGAH, 3 sh; Prov. Asturias, near N625 in N. part of Desfiladero de los Beyos (by turn to San Ignacio), 30T 033001/478728, 2011.05.13, GAH & DTH E159, CGAH, 49 sh; Prov. Barcelona, Castelldefels, 41°17´N, 1°59´E, undated, JSTA 1799, CGAH, 4 sh; Prov. Cantabria, Desfiladero de la Hermida, by N621 3 km NW. of La Hermida, 43°17´N, 4°38´W, 2001.05.22, GAH, CGAH, 19 sh; Prov. Córdoba, 2 km NE. of Cabra, UG4 (37°30´N, 4°25´W), 1984.07.10, DTH, MH & MBS 1984.90.12, NMW.Z.1993.052.10040, 10 sh (4 ad); Prov. Girona, W. of N152 at Campedevanol (N. of Ripoll), 42°13´N, 2°10´E, 2001.06.16, GAH 2001/37, CGAH, 184 sh; Prov. Granada, Castril, Acequia en Sierra de Castril, 30SWG2085, 2010.05., JSTA, CJSTA 11266; Prov. Logroño, by N111 6 km S. of Torrecillas en

Cameros, 42°12´N, 2°38'W, 1986.06.22, DTH, MH & MBS 1986.50.3, NMW.Z.1993.052.13057, 68 sh (40 ad); Prov. Málaga, Torremolinos, Alrededores arroyo Cueva e la Higuera, Sierra Llana, 30SUF6354, 1991.03., 1992.01. and 1993.12., JSTA, CJSTA 2337; Prov. Murcia, E. slope of Espuña, 30S 062597/419158, 2006.12.16, GAH 2006/03, CGAH, 2 sh; Prov. Tarragona, by N340, 3 km SW. of Hospitalet de l'Infant, CF2, 1984.07.06, DTH, MH & MBS 1984.65.1, NMW.Z.1993.052.09829, 51 sh (31 ad); Prov. Vizcaya, by BI2543 near Dima, 30T 05209/47746, 2011.05.09, GAH & DTH E151, CGAH, 1 sh.

T. callicratis?: Spain, Prov. Girona, by C260 1.5 km W. of Vilafant, DG3, floodline debris from beside River Manol, 115 m, 1983.08.24, DTH & MBS 1983.147.20a, NMW.Z.1993.052.08027, 54 sh (36 ad, 13 imm, 5 very long shells without peristome lip).

T. claustralis: France, Dept. Dordogne, near Grotte des Combarelles just S. of D47 *ca* 2 km E. of Les Eyzies-de-Tayac, 44°57´N, 1°03´E, 2001.06.30, GAH, CGAH, 85 sh.

T. cylindrica: France, Dept. Hautes-Pyrénées, 3 km SE. of St. Marie-de-Campan, 42°58´N, 0°15´E, 1980.08.25, DTH 1981.32.2, NMW.Z.1993.052.04464, 23 sh (13 ad); N. of D923 8.2 km SW. along road from Gavernie, 42°44´N, 0°30´E, 2001.06.28, GAH, CGAH, 20 sh; Dept. Yonne, by N6 at Nailly Saint-Moré, EN3 (47°35´N, 3°47´E), 1983.09.27, DTH & MBS 1983.341.6, NMW.Z. 1993.052.09392, 26 sh, showing some characters of "*T. arcyensis*" (see text); Great Britain, Bedfordshire, Potton, UK grid: 52/229494, 1977.04.07 and 1977.06.06, DTH & RBGW 1977.140.1, NMW.Z.1993.052.02393, 167 sh (20 ad).

T. cylindrica?: France, Corse, 1 km NE. of Tavera, W. of Bocognano, 42°04´N, 9°01'E, 1977.04.15, DTH 1977.96b.1, NMW.Z.1993.052.02063, 1 sh (nearly ad); Dept. Haute-Savoie, N.-facing slope of Salève above Collonges, 46°08´N, 6°10´E, 1976.12.27, DTH 1976.230.5, NMW.Z.1993.052.01508, 61 sh (16 ad); Portugal, Trás-os-Montes, C. Bragança, Bragança, 29T PG8730, 2008.08.16, ÁDO BGÇ/08, CÁDO, 2 sp (*T. cylindrica* or possibly big *T. callicratis*).

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A new species and range extension of *Ponderinella* (Gastropoda, Tornidae) in West Africa

Una nueva especie y extensión del área de *Ponderinella* (Gastropoda, Tornidae) en África occidental

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ABSTRACT

Two species with similar shell characters collected on the Gabon coast are studied. One of them is here described while the other was already described in the genus *Notosetia* from the Ghana coast. The generic assignation is discussed concluding that tentatively it is better that both (close to *P. minutissima*) should be placed in the genus *Ponderinella*.

RESUMEN

Se estudian dos especies con concha de caracteres similares recolectadas en la costa de Gabón. Una de ellas es nueva para la ciencia y se describe aquí, y otra ya había sido descrita en el género *Notosetia* en la costa de Ghana. Se discute la asignación genérica concluyendo con que tentativamente es mejor que las dos (próximas a *P. minutissima*) queden situadas en el género *Ponderinella*.

INTRODUCTION

The genus *Notosetia* Laseron, 1954 was introduced for species of New Zealand, designating species with simple, smooth and rather featureless shells (Powell, 1979). Ponder (1985) placed this genus as synonym of *Putilla* A. Adams, 1867, based on species from Japan, also smooth but very solid. He also considered *Wanganella* Laseron, 1954 with similar doubts as to its being a synonym. Some species figured by Ponder (1985) and by Powell (1979) show minute shells, which are smooth, with very scarce spiral sculpture, a small umbilicus, rounded by several cords, simple aperture and a sharp external lip.

Rolán & Gubbioli (2000) and Rolán & Ryall (2000) described from Mauritania and Ghana respectively two species with these similar characters: white, smooth, brilliant, small umbilicus, scarce spiral microsculpture, and one of them with a subsutural canal. They were placed in *Wanganella* and *Notosetia* lacking better genera for these characters. In one of them (*Wanganella ruedai*) the operculum and radula were examined and they show affinity to species of the familia Skeneidae. The reasons for employing the genus *Notosetia* are given in the original description,the main one being the fact that the genus *Putilla* could be a synonym of *Paludinella* Pfeiffer, 1841.

The genus *Elachisina* Dall, 1918 is different having shells usually more

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fragile, without peripheral angulation, constant spiral sculpture of cords or grooves, and typical umbilicus with a straight cord.

In a recent trip of one of the authors (ER) sediments from Gabon were collected. When examined there appeared shells of two species agreeing with the above mentioned characters. One of them seems to be identical to *Notosetia ghanensis* Rolán & Ryall, 2000, being the second record for this species after its description and representing a new record for Gabon. The second species is new and is described in the present work.

During the study of this material, new generic possibilities were evaluated. The most acceptable was *Ponderinella* Marshall, 1988. This genus is based on minute shells, which are depressed-turbiniform, thin, glassy, smooth, and umbilicate. Protoconch of about 1.3 whorls; teleoconch with convex whorls, base and umbilical rim angulate. In Rolán & Rubio (2002), this genus was employed for some African species, some of them (*Ponderinella skeneoides* and *P. minutissima*) being very close to the species we have found in Gabon, even with a similar protoconch with microsculpture in the embryonic shell and microsculpture of minute tubercles on the teleoconch. For these reasons, we decided (in the absence of soft parts of this material) to place the species previously considered a *Notosetia* and the new taxon in the genus *Ponderinella*, considering that both of them and *P. minutissima* must be congeneric.

For the placement of these species we have considered they were not a skeneid because the species of this group have usually a paucisppiral protoconch with one or a little more whorls and direct development. In opposition, the Tornidae have multispiral planktotrophic protoconchs, with separation between protoconch I and II, as in the *Ponderinella* species studied from West Africa.

SYSTEMATIC PART

Family Torniidae Sacco, 1896
Genus *Ponderinella* Marshall, 1988

Type species: *Ponderinella lignicola* Marshall, 1988.

Ponderinella ghanensis (Rolán & Ryall, 2000) new. comb. (Figs. 1-6)

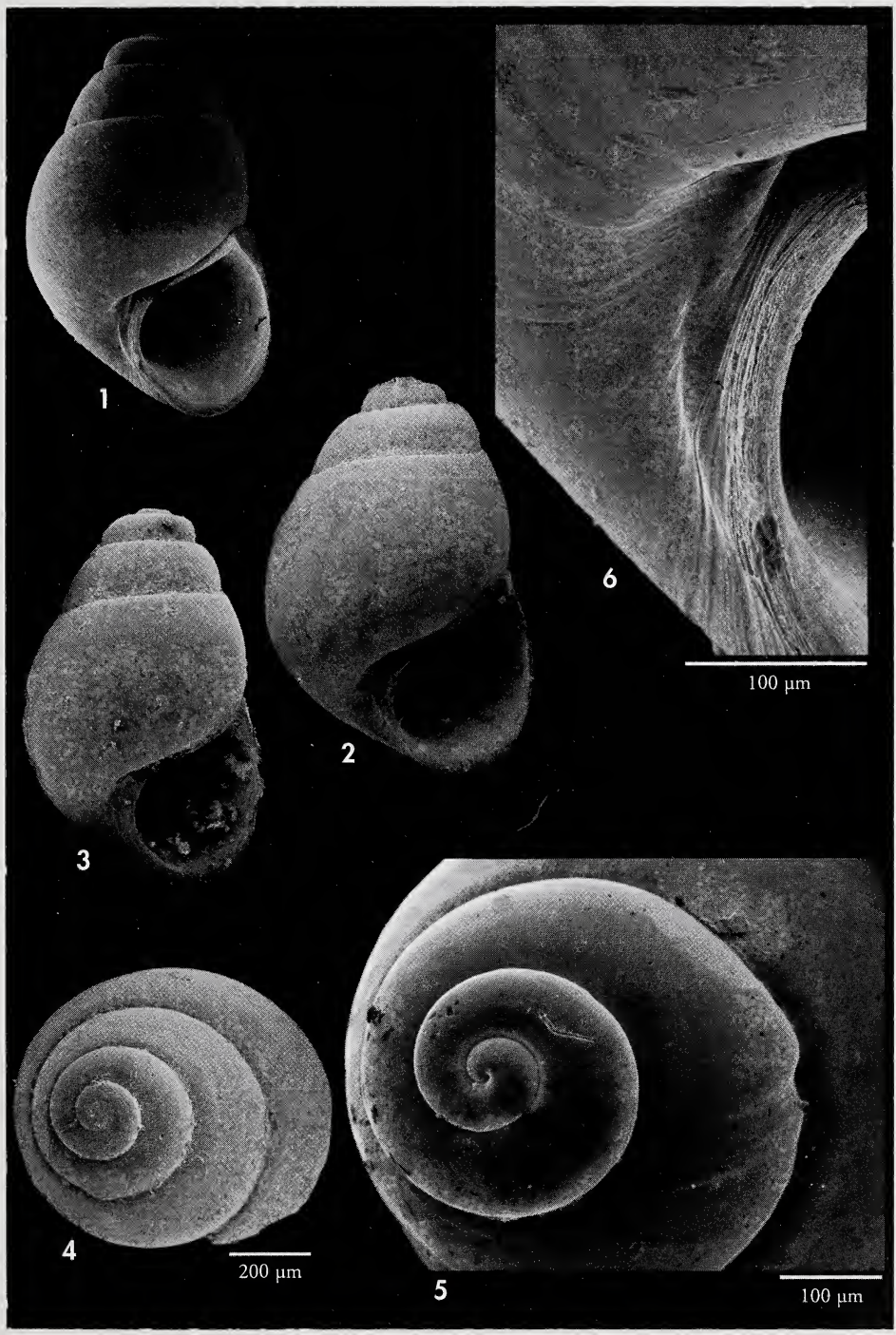
Notosetia ghanensis Rolán & Ryall, 2000: 39-41, figs. 1-7.

Material studied: Ghana: Holotype and paratypes (see Rolán & Ryall, 2000) . Gabon: 7 shells in intertidal sediments, Cape Esterias; 2 s in sediments, Cape Santa Clara (both collecting in September 2011).

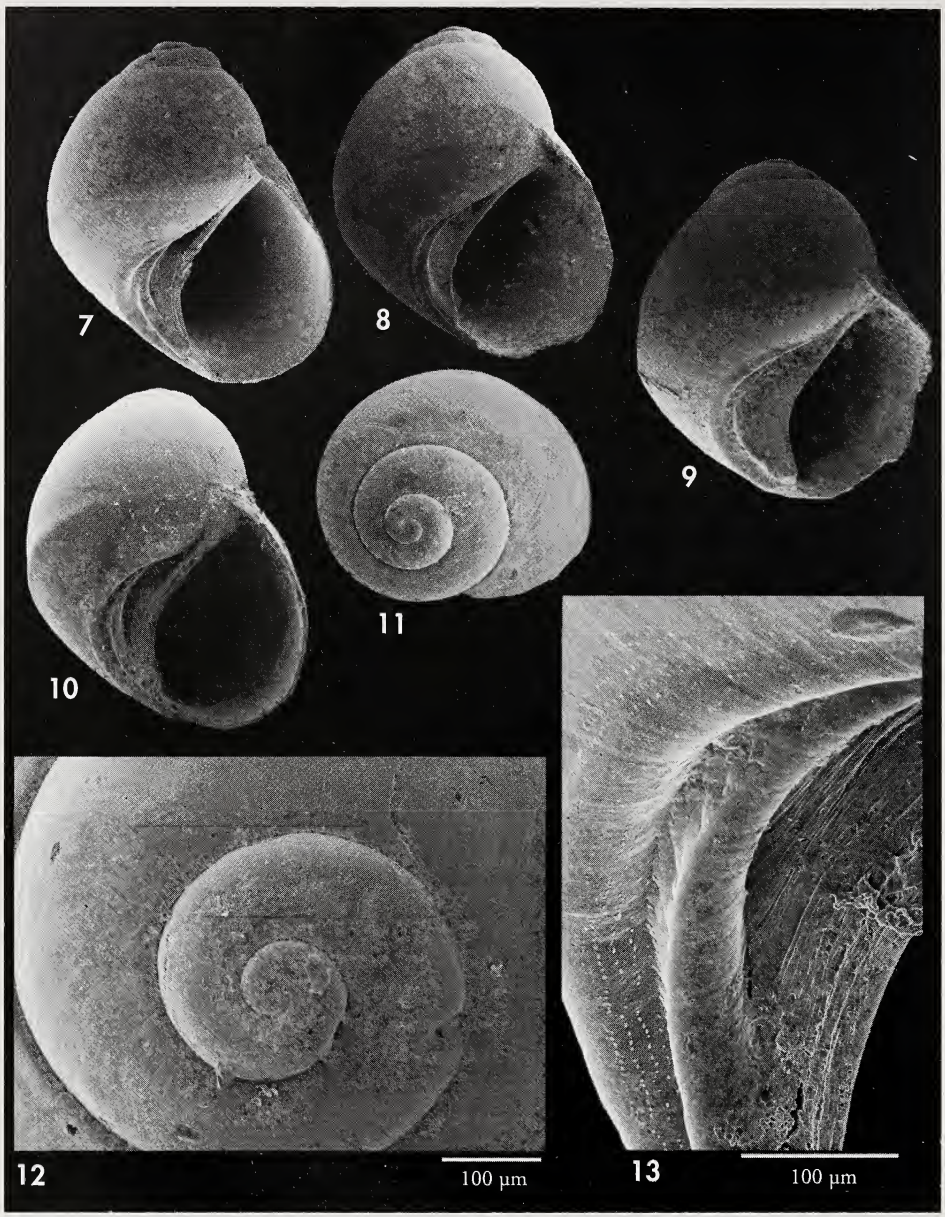
Description: See Rolán & Ryall (2000). The protoconch was described as having only ¾ of whorl. But this is only the embryonic part. The complete larval is about 2 ½ smooth whorls. The protoconch has a diameter of about 440 μm and finishes in a thickened separation with the teleoconch. The latter has about 1 ¾ whorls and has on its first whorl fine spiral oblique zigzag lines, which disappear on the second and the last whorl, except for some fragments near the umbilicus. On the periphery of the last whorl there is a slight angulation in the level of contact with the external lip. Aperture ovoid, slightly angled; external lip sharp at the base; columella very arched, which does not close the umbilicus, reduced to a fissure, delimited by a strong cord.

Distribution: Only known from Ghana and now from Gabon.

Remarks: The material studied from Gabon is very similar to that of the original description.



Figures 1-6. *Ponderinella ghanensis* (Rolán & Ryall, 2000). 1-3: shells, 1.1, 1.2, 1.1 mm, Cape Esterias, Gabón (MHNS); 4: shell, apical view; 5: protoconch; 6: details of the aperture.
Figuras 1-6. Ponderinella ghanensis *(Rolan y Ryall, 2000). 1-3: conchas, 1,1; 1,2 y 1,1 mm, Cabo Esterias, Gabón (MHNS) 4: concha, vista apical; 5: protoconcha, 6: detalles de la abertura.*



Figures 7-13. *Ponderinella gabonensis* spec. nov. 7: holotype, 1.25 mm (MNHN); 8-11: paratypes, 1.3, 1.27, 1.3, 1.1 mm (MHNS); 12: protoconch; 13: detail of the umbilicus.
Figuras 7-13. Ponderinella gabonensis *spec. nov. 7: holotipo, 1,25 mm (MNHN); 8-11: paratipos, 1,3; 1,27; 1,3 y 1,1 mm (MHNS); 12: protoconcha; 13: detalle del ombligo.*

Ponderinella gabonensis spec. nov. (Figs. 7-13)

Type material: Holotype in Museum National d'Histoire Naturelle (MNHN, 25140) (Fig. 7). Paratypes: Museo Nacional de Ciencias Naturales (MNCN), Museo de Historia Natural de Santiago de Compostela (MHNS) (12 s, 100571).

Type locality: Cape Esterias, Gabón, in intertidal sediments.
Etymology: The specific epithet is from the country where the species was found.

Description: Shell of small size, a little pyriform entirely smooth, not strong, with a spire formed by 3 ¾ whorls separated by a deep suture. Protoconch with 1 ¾ whorls of smooth surface except its embryonic part which is slightly rough; largest diameter of about 320 μm. Teleoconch formed by 2 whorls, which are totally smooth except fine growth lines and small microtubercles aligned spirally in the basal area and the external umbilical cord. In the last whorl there is a distinct periferal angle. Aperture ovoid, angled on its upper part; external lip sharp at the border, not reflected at the base, forming two small interruptions at the contact with the two periumbilical cords. The umbilicus is limited by these two cords, having in the inner part strong growth lines.

Dimensions: Holotype height is 1.25 mm, width 1.0 mm; maximum height paratypes is 1.3 mm.

Distribution: Only known from Gabón.

Remarks: The only species with some similarity in shell characters are *Ponderinella ghanensis* (Rolán & Ryall, 2000) and *Ponderinella minutissima* Rolán & Rubio, 2002.

Ponderinella gabonensis spec. nov. can be distinguished from *P. ghanensis* by its more evident peripheral angulation, the wider umbilicus, delimited by two cords, lack of ornamentation on first teleoconch whorls, and having fine microtubercles on the basal and periumbilical cords.

Also the new species has some similarity to *P. minutissima*, mainly in their general aspect, ornamentation and protoconch. But the new species has a more marked peripheral angulation and the umbilicus has two spiral cords.

ACKNOWLEDGEMENTS

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A new species of *Bornia* (Bivalvia: Galeommatoidea) from southern Spain

Una nueva especie de *Bornia* (Bivalvia: Galeommatoidea) del sur de España

Serge GOFAS*

Recibido el 27-III-2012. Aceptado el 11-V-2012

ABSTRACT

A new species *Bornia aartseni* is described from a shallow soft bottom near Benalmádena, southern Spain. The species is compared to the widespread *Bornia sebetia* (Costa, 1829) and *B. geoffroyi* (Payraudeau, 1826). Hinges and protoconchs are illustrated with scanning electron microscopy. *Bornia sebetia* var. *triangula* (Pallary, 1920), is listed as a synonym and a syntype is figured.

RESUMEN

Se describe una nueva especie *Bornia aartseni* en un fondo blando somero cerca de Benalmádena, sur de España. La especie se compara con las de más amplia distribución, *Bornia sebetia* (Costa, 1829) y *B. geoffroyi* (Payraudeau, 1826). Se ilustran con microscopía electrónica de barrido las charnelas y protoconchas. *Bornia sebetia* var. *triangula* (Pallary, 1920), se considera como un sinónimo de *B. sebetia*, del que se ilustra un sintipo.

INTRODUCTION

The genus *Bornia* comprises small bivalves which are usually found in secluded habitats of the infralittoral zone. The type species, *Bornia sebetia* (Costa, 1829), is widespread in the Mediterranean sea and the genus has been used to accommodate about a dozen species worldwide (WoRMS, 2012), some of which very tentatively assigned to the genus.

Four species are hitherto reported from the Mediterranean and Eastern Atlantic (Hoeksema and Simons, 2011). Here an additional species found in a coastal environment in southern Spain is described as new.

MATERIALS AND METHODS

Specimens of *Bornia sebetia* from various parts of the Mediterranean, but particularly from the same localities where the new species was collected, were used as comparative material and for a correct orientation of the valves with reference to a complete specimen with soft parts.

Most of the material of the new species was collected during operations for the replenishment of the beach of Benalmádena, province of Málaga, next to the marina. Sand was extracted at the location indicated as type locality by pumping, and delivered to the beach through a pipeline, thereby stranding

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many animals of the infauna. This operation was carried out in June 2003 and again in November 2011. A single valve was collected in shore drift at Calahonda, further to the West on the coast of Málaga.

Selected specimens were cleaned by soaking in 10% solution of sodium lauryl-sulphate and sonicated in water, then dried, mounted on a stub and metallised for examination under the scanning electron microscope.

SYSTEMATICS

Bornia aartseni spec. nov. (Figures 1 A-G, 3 A-C)

Holotype: complete shell, 3.0 mm, in Muséum National d'Histoire Naturelle, Paris (catalogue number: Moll 25155).
Paratypes: complete shell, 2.9 mm; 2 left valves, 3.0 and 2.7 mm; 3 right valves, 2.8, 2.7 and 2.4 mm, all from the type locality, June 2003; complete shell, 2.7 mm, 7 left valves (2.0 to 2.8 mm) and 7 right valves (1.9 to 2.8 mm), all from the type locality, November 2011, in MNHN (catalogue number: Moll 25156); 1 left valve, Calahonda (36° 29.4′ N, 04° 41.8′ W, 0-1 m), 2.2 mm, in MNHN (catalogue number 25157).
Type locality: Benalmádena Costa, Málaga, Spain (36°35.6′N, 04°30.9′W, 5 m)
Etymology: Dedicated to Jacobus J. van Aartsen (NMNH, Leiden, The Netherlands), who extensively studied this group of microbivalves and had the intuition that this was something different.

Description: Shell up to 3 mm long, subtrigonal in shape with small, prominent umbos, equivalve and equilateral, flattened. Valves completely appressed on all margins, which are smooth and thin. Antero-dorsal margin nearly straight, gradually merging into a rounded anterior margin; postero-dorsal margin slightly convex, also gently merging into the rounded posterior margin; both anterior and posterior margins gradually merging into the slightly convex ventral margin. External surface smooth and glossy, with conspicuous growth lines.

Prodissoconch slightly convex, ovate in outline, 260 to 280 μm in its greater diameter, delimited from dissoconch by a distinctly incised line. Prodissoconch 1 reaching ca. 100 μm in its greater diameter; quite distinct, oval-elongate; external surface of prodissoconch 1 slightly rugose, of prodissoconch 2 smooth.

Hinge plate narrow, interrupted under the umbo by a small notch which receives the internal ligament. Left valve with two cardinal teeth (2a and 2b) anterior to the ligament pit, the most anterior one elongate and nearly parallel to the antero-dorsal margin, the posterior one small, narrow and oriented vertically; posterior to the ligamental pit is a strong lateral tooth (PII), elongate and parallel to the postero-dorsal margin. Right valve with a strong, very oblique cardinal tooth (1) anterior to the ligamental pit, pointing towards an antero-ventral direction and overhanging the edge of the cardinal platform; posterior to the ligamental pit is one very strong and thick lateral tooth (PI) nearly parallel to the postero-dorsal margin and also overhanging the edge of the platform. The anterior tooth of the right valve seems compound, with a thicker segment close to the umbo pointing downwards, and a thinner distal part pointing forwards.

Interior of valves smooth, with muscle scars and pallial line usually very distinct due to more transparency of the shell material. Muscle scars proportionally very small with a diameter in the order of $1/10^{th}$ of the shell length. Pallial line thick, starting from the muscle scars and running quite close to the shell margin, the distance between the outer edge and the ventral margin being about $1/8^{th}$ of shell height. On the posterior side, the pallial line makes an inflexion inwards just below the muscle scar. The surface within the pallial line has a frosty appearance.

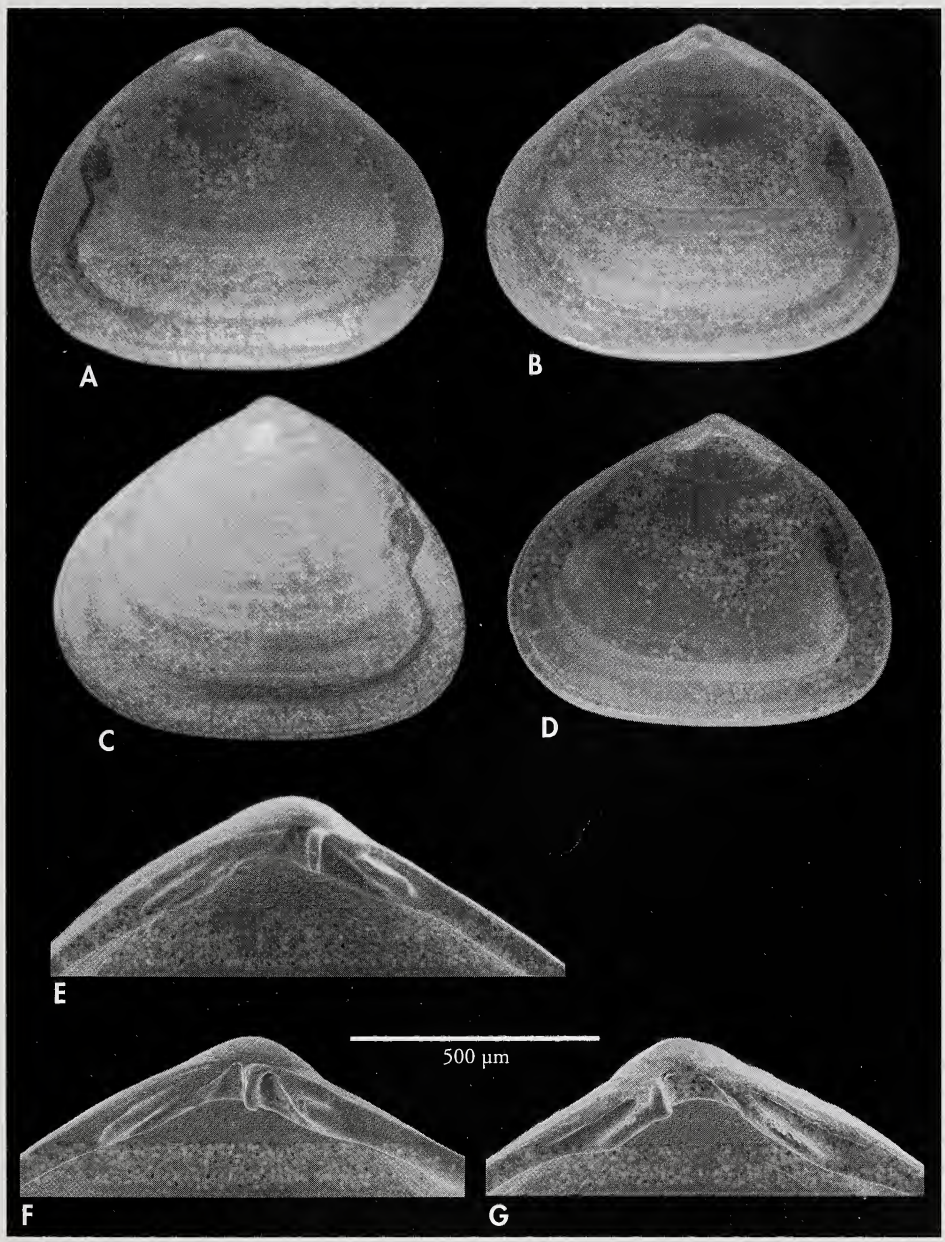

Figure 1. *Bornia aartseni* spec. nov. A, B: interior of left and right valves of the holotype from Benalmádena, actual length 3.0 mm; C: exterior of the left valve of the holotype; D: interior of the right valve of a bivalved paratype from Benalmádena, actual length 2.9 mm; E: hinge of a left valve from Calahonda; F: hinge of a left valve from Benalmádena; G: hinge of a right valve from Benalmádena.

Figura 1. Bornia aartseni *spec. nov. A, B: interior de las valvas izquierda y derecha del holotipo, Benalmádena, longitud real 3,0 mm; C: exterior de la valva izquierda del holotipo; D: interior de la valva derecha de un paratipo bivalvo, Benalmádena, longitud real 2,9 mm; E: charnela de una valva izquierda, Calahonda; F: charnela de una valva izquierda, Benalmádena; G: charnela de una valva derecha, Benalmádena.*

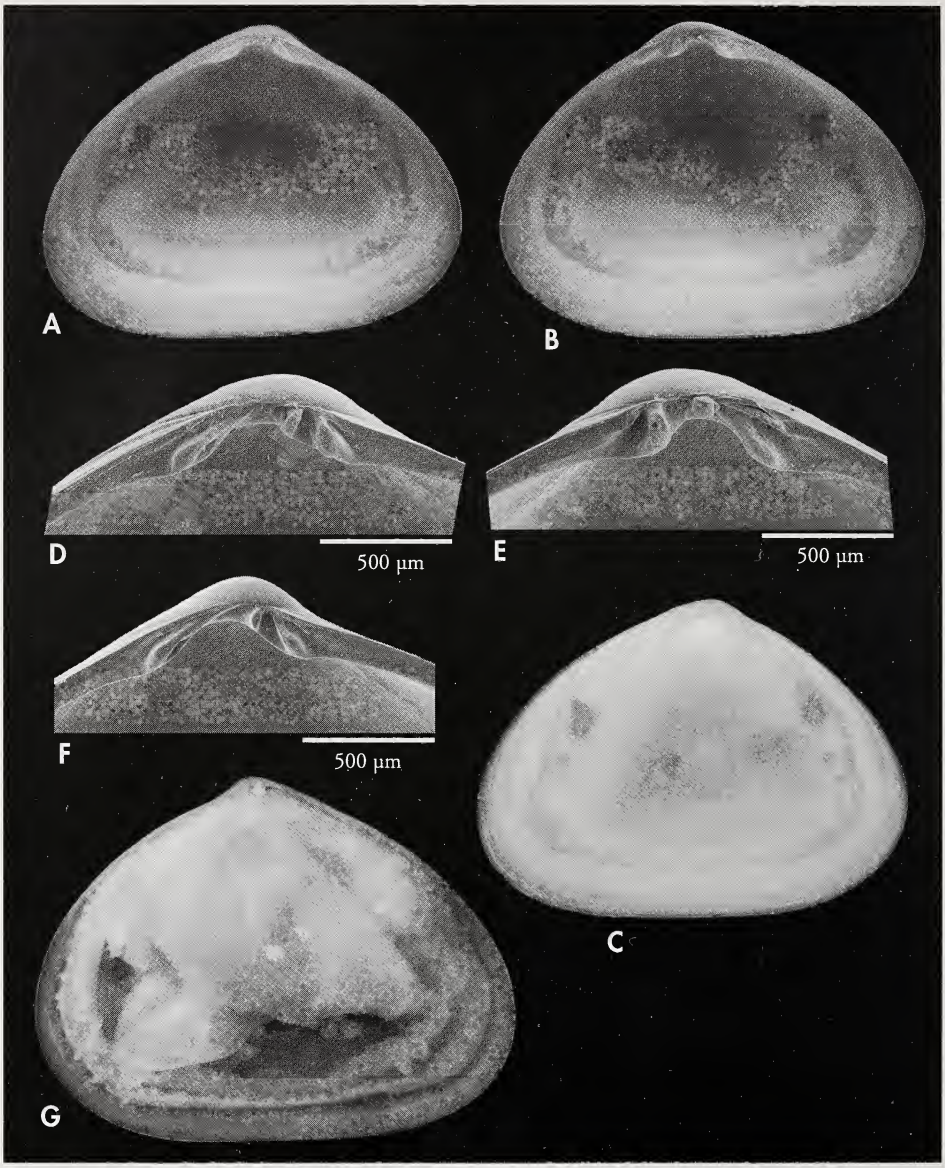

Figure 2. *Bornia sebetia* (Costa, 1829). A, B: interior of left and right valves of a specimen from Calahonda, actual length 4.2 mm; C: exterior of the right valve of the same specimen; D, E: hinge of the left and right valves of the same specimen; F: hinge of a left valve from Benalmádena; G: inside of a preserved specimen from Benalmádena, viewed from the left side with left valve and mantle lobe removed, showing the anterior tongue-like foot and the two developed demibranchs. The small spots in the mantle cavity are brooded embryos at an early stage of development.

Figura 2. Bornia sebetia *(Costa, 1829). A, B: interior de las valvas izquierda y derecha de un ejemplar de Calahonda, longitud 4,2 mm; C: exterior de la valva derecha del mismo ejemplar; D, E: charnela de las valvas izquierda y derecha del mismo ejemplar; F: charnela de una valva izquierda de Benalmádena; G: interior de un ejemplar de Benalmádena, visto desde el lado izquierdo con valva izquierda y el lóbulo del manto eliminados, mostrando el pie anterior en forma de lengua y las dos hemibranquias desarrolladas. Las manchas pequeñas en la cavidad del manto son embriones incubados una etapa temprana de desarrollo.*

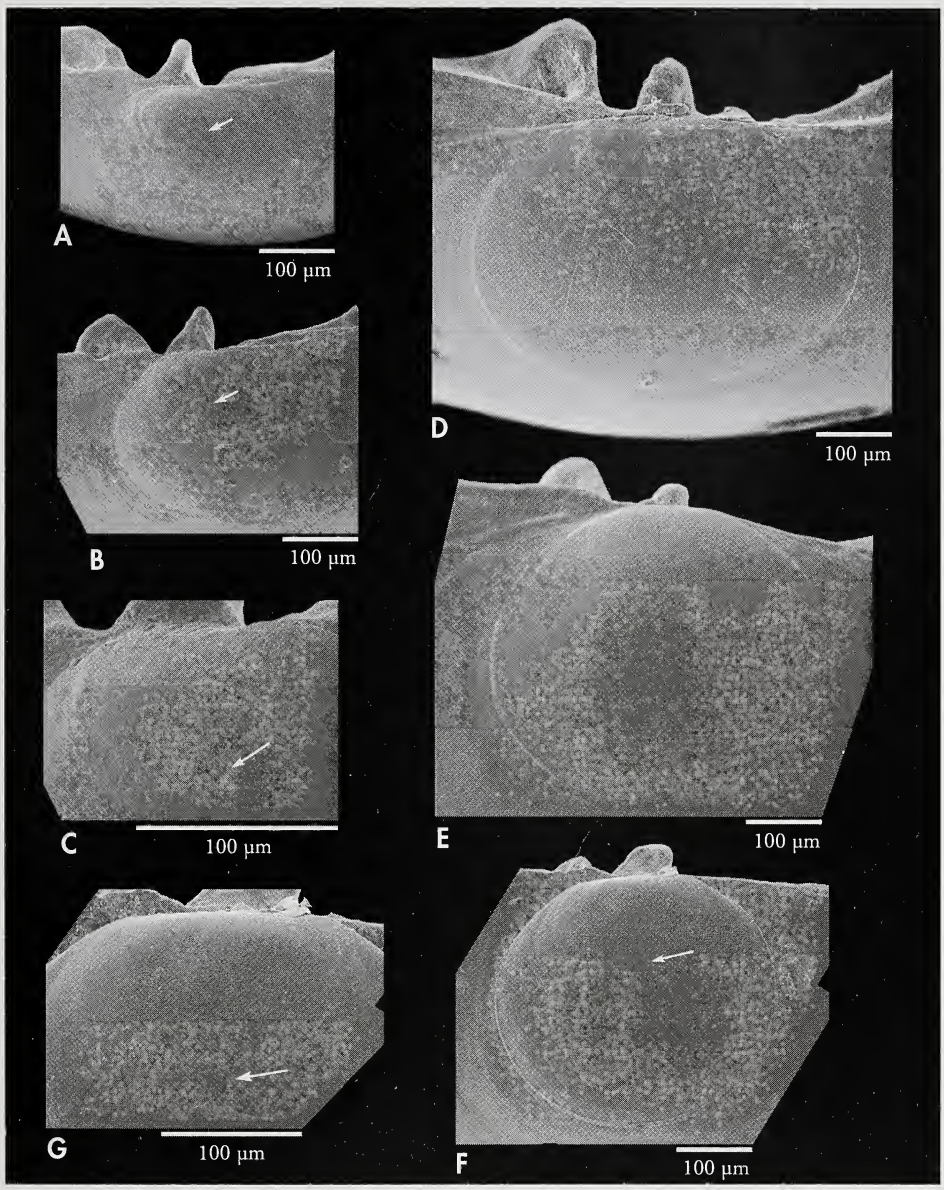

Figure 3. Prodissoconchs of *Bornia* spp. A: *Bornia aartseni* spec. nov. from Calahonda, same valve as figure 1E; B: *Bornia aartseni* spec. nov. from Benalmádena, same valve as figure 1F; C: enlarged view of prodissoconch 1 of the same valve; D: *Bornia sebetia* (Costa, 1829), left valve from Calahonda, viewed with ventral margin tilted backwards; E: *Bornia sebetia*, left valve from Benalmádena; F: *Bornia geoffroyi* (Payraudeau, 1826), right valve from Calahonda; G: enlarged view of prodissoconch 1 of the same protoconch. Arrows show the transition from prodissoconch 1 to prodissoconch 2.

Figura 3. Prodisoconchas de Bornia *spp. A:* Bornia aartseni *spec. nov. de Calahonda, misma valva que la figura 1E; B:* Bornia aartseni *spec. nov. de Benalmádena, misma valva que la figura 1F; C: vista ampliada de la prodisoconcha 1 de la misma valva; D:* Bornia sebetia *(Costa, 1829), valva izquierda de Calahonda, vista con el margen ventral inclinado hacia atrás; E:* Bornia sebetia, *valva izquierda de Benalmádena; F:* Bornia geoffroyi *(Payraudeau, 1826), valva derecha de Calahonda; G: vista ampliada de la prodisoconcha 1 de la misma valva. Las flechas señalan la transición de prodisoconcha 1 a prodisoconcha 2.*

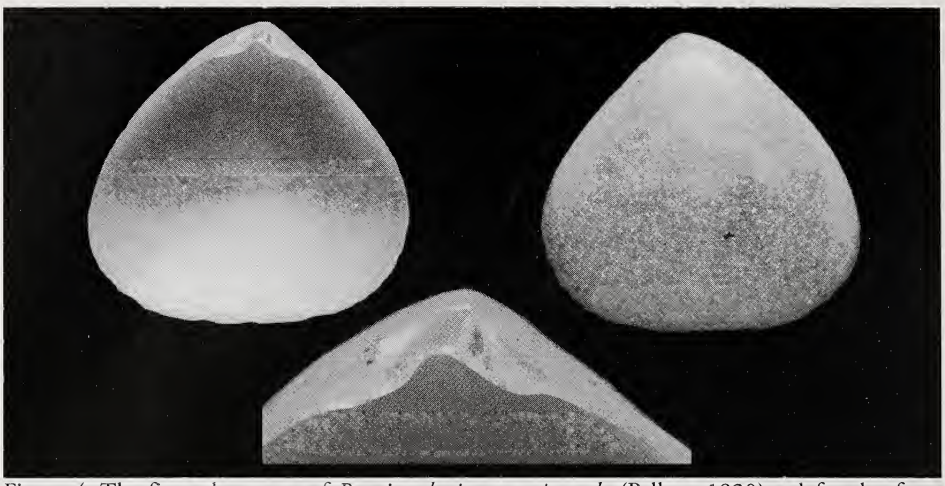

Figure 4. The figured syntype of *Bornia sebetia* var. *triangula* (Pallary, 1920), a left valve from Mazagan (now El Jadida, Atlantic coast of Morocco), in Muséum National d'Histoire Naturelle, Paris (catalogue number: Moll 25158). Actual length 6.0 mm.

Figura 4. El sintipo de Bornia sebetia *var.* triangula *(Pallary, 1920), de Mazagan (ahora El Jadida, costa atlántica de Marruecos), en el Museo Nacional de Historia Natural de París (número de catálogo: Moll 25158). Longitud real 6,0 mm.*

Discussion: The homology of hinge teeth in the Galeommatoidea is far from being straightforward, and the above description follows the interpretation of Chavan in Moore (1969) of the teeth situated in front of the ligamental pit as cardinals (2a and 2b on the left valve, 1 on the right valve) and of those situated behind it, as laterals (PII on the left valve, PI on the right valve). This is also the interpretation followed by Hoeksema and Simons (2011) in their description of the Canarian species. It is however debatable whether the most anterior tooth could be considered as an anterior lateral, or even as a compound tooth where only the distal part would be homologous to a lateral, as suggested by the morphology seen on figure 1G. It is far beyond the scope of this paper to reassess the homology of teeth, which would need access to large ontogenetic series in many species.

This new species was figured by van Aartsen (1997: 44, fig. 30) as *Bornia sebetia* var., represented by two valves 2,6 mm in length and proceeding from the area of Malaga.

Bornia sebetia (Costa, 1829) is the most similar species. The name was originally made available in the caption of a figure (Costa, 1829:131; pl. 2 fig. 6), and the species was described only ten years later (Costa, 1839: 190-191). It was believed by Costa (1839) to be a freshwater species, with a type locality "foci del Sebeto" (mouth of the river Sebethus, in the eastern part of downtown Naples). This was the reason for which Philippi (1836: 14) dismissed the name, although he was aware of it, and redescribed the species as *Bornia corbuloides*. The latter name was universally used until Bucquoy, Dautzenberg and Dollfus (1892: 236) restored the specific name *sebetia*, now in usage, on the grounds of priority. *Bornia corbuloides* is type species of the genus by subsequent designation (Stoliczka, 1871: 266).

Compared to *Bornia aartseni* spec. nov., *Bornia sebetia* is considerably larger (more than twice), and has much more rounded, less prominent umbos. The prodissoconch is in proportion almost twice as large (450-500 μm). The hinges are also different, although they have the same general setting of the genus. On the left valve, the rather small tooth immediately anterior to the ligamental

pit, convincingly interpreted as a cardinal tooth (2b), is vertical in *Bornia aartseni* spec. nov. and pointing towards posterior in *B. sebetia*; the anteriormost tooth, interpreted as an anterior cardinal (2a) following HOEKSEMA AND SIMONS (2011), is narrow and nearly parallel to the antero-dorsal margin in *Bornia aartseni* spec. nov., thick and pointing downwards in *B. sebetia*. On the right valve, both teeth are considerably narrower and more parallel to the margins in *Bornia aartseni* spec. nov. than in *B. sebetia*. The pallial line is situated proportionally much closer to the ventral margin in *Bornia aartseni* spec. nov. than in *B. sebetia*, it is less ragged on its inner edge and starts from the muscle scars proper, not somewhat outwards like in *B. sebetia*. The inner surface of *B. sebetia* shows faint radial lines, backed by inner structures of the shell, whereas the inner surface of *Bornia aartseni* spec. nov. has a frosty, non-lineated surface.

Kellya (Bornia) sebetia var. *triangula* Pallary 1920 (p. 84, pl. 1 fig. 21) is based on a very worn left valve (Figure 4) from Mazagan (now El Jadida, Morocco). This specimen is proportionally higher than typical *Bornia sebetia*, but otherwise fits the size range and hinge characters of this species, as described above. It may be a specimen with abnormal growth and, unless further collecting reveals a separate species with these proportions on the Atlantic coast of Morocco, should be maintained in the synonymy of *Bornia sebetia*.

Bornia canariensis Hoeksema and Simons, 2011, described from the island of Gran Canaria, is markedly smaller (less than half the size of *Bornia aartseni* spec. nov.) and yet has a proportionally thicker hinge plate. On the left valve, the tooth situated posterior to the ligament is parallel to the postero dorsal margin in both species, but not so much on the right valve where it is more like *B. sebetia* than like *Bornia aartseni* spec. nov.

Other species reported in the area are considerably different and may even not be congeneric. *Bornia geoffroyi* (Payraudeau, 1826), placed in the genus *Semeloidea* Bartrum & Powell, 1928 by CHAVAN (1969) and VAN AARTSEN (1997), is considerably larger (up to 15 mm) and flatter, has anteriorly to the ligament very short cardinal teeth pointing downwards, two on the left valve and one on the right valve; posterior to the ligament each valve bears one very long posterior tooth nearly parallel to the postero-dorsal margin. *Bornia balalaika* Cosel, 1995 has a distinctive outline in which anterior and posterior margins make a right angle with the ventral margin, and is described as having two cardinal teeth on each valve (VON COSEL, 1995).

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Gasterópodos marinos de las islas Columbretes (Mediterráneo occidental)

Marine gastropods of the Columbretes Islands (Western Mediterranean)

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RESUMEN

Se estudian varias muestras de sedimentos bioclásticos recogidas con escafandra autónoma en distintos puntos de las islas Columbretes. Como resultado se obtuvieron un total de 257 especies de gasterópodos, de las cuales 119 constituyen nuevas citas para este enclave insular y una del género *Crisilla* se describe como nueva para la ciencia. Se comentan los problemas taxonómicos que presentan diversas especies de los géneros *Dikoleps, Crisilla, Chauvetia* y *Cima*, o de las familias Cerithiopsidae y Omalogyridae. Por último, se ofrecen unas consideraciones generales sobre la malacofauna marina de estas islas.

ABSTRACT

Several samples of bioclastic sediment collected by scuba diving at various places of the Columbretes Islands (E Spain) have been studied. As a result, a total of 257 species of gastropods were obtained, of which 119 are new records for these islands, and one species of the genus *Crisilla* is described as new to science. Some taxonomic comments are given on species of the genera *Dikoleps, Crisilla, Chauvetia,* and *Cima,* and on the families Cerithiopsidae and Omalogyridae. Finally, some general remarks on the marine malacofauna these islands are presented.

INTRODUCCIÓN

La catalogación de la biodiversidad es un trabajo colectivo que dista mucho de haberse concluido y que es urgente a causa de su progresiva merma, asociada al deterioro ambiental, que lleva aparejada la extinción de muchas especies. Los inventarios faunísticos exhaustivos y realizados con rigor taxonómico constituyen una necesaria base científica permanente para documentar los patrones de diversidad en hábitats, ecosistemas o zonas geográficas (Mikkelsen y Cracraft, 2001). La información que proporcionan es esencial para identificar endemismos, posibles especies invasoras, especies indicadoras de cambios ambientales, especies en declive, posibles especies nuevas, o para documentar cambios en la distribución de las especies debido al cambio global o a los diferentes impactos provocados por el hombre. Todo ello debe servir de base para establecer los planes de conservación más adecuados.

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Desafortunadamente, por lo general, la conservación se centra sólo en unas pocas especies (ver Martín-López, Montes, Ramírez y Benayas, 2009), ya sean las que aparecen en las "listas rojas" de especies amenazadas o aquellas consideradas "especies clave" o con un papel ecológico esencial, como son las especies dominantes o estructuradoras. En consecuencia, la conservación de la biodiversidad sólo toma en cuenta una ínfima parte de ella e ignora el enorme elenco de especies raras y poco conspicuas. Quizá cada una de estas pequeñas species por si sola tenga un papel irrelevante, pero es el conjunto de todas ellas lo que sostiene la biodiversidad y las redes tróficas. Por otro lado, debido a lo que se ha llamado el "impedimento taxonómico" (por la IUBS/Diversitas, Systematics Agenda, 2000), que hace referencia a la falta de buenos taxónomos y el elevado tiempo y esfuerzo que supone la identificación a nivel específico de todos los ejemplares), muchas estimas de la diversidad se basan en el número de taxones de rango supraespecífico (géneros, familias ...). Es lo que denominan "suficiencia taxonómica" (ver, por ejemplo, Terlizzi, Bevilacqua, Fraschetti, Boero, 2003), arguyendo que los taxones de rango superior son suficientes como estima de la biodiversidad. Indudablemente, son una estima, pero una estima con un grado de precisión grosero por razones obvias. Dos enclaves o zonas geográficas pueden tener un mismo número de géneros o de familias, pero diferir mucho en el número de especies. Por ello, son las especies la unidad de medida de la biodiversidad más precisa y adecuada.

En lo que se refiere a los moluscos, el conocimiento que se posee de la malacofauna marina española, aunque puede considerarse satisfactorio y se cuenta con detallados inventarios de muchas zonas, todavía no existe una obra de conjunto posterior a la de Hidalgo (1917). Tenemos una idea bastante aproximada de las especies presentes en nuestras aguas, pero no se conocen con precisión los límites de distribución de la mayor parte de ellas, cómo varía su abundancia de unas zonas a otras o si se encuentran en regresión o expansión, entre otros muchos aspectos. Afortunadamente, en los últimos años, y a pesar de las modas imperantes, parece haberse intensificado la publicación de inventarios exhaustivos de los moluscos de distintas áreas (Giribet y Peñas, 1997; Peñas y Giribet, 2003, Peñas, Rolán, Luque, Templado, Moreno, Rubio, Salas, Sierra y Gofas, 2006; Tarruella Ruestes y Lopez Soriano, 2006; Oliver baldoví, 2007; Peñas, rolán y ballesteros, 2008; Peñas, Rolán y Almera, 2009, entre otros), lo que ha permitido, entre otras cosas, la detección y discripción de un buen número de especies nuevas, a la vez que completar los conocimientos sobre la distribución de nuestra malacofauna marina. Cabe destacar también la reciente publicación de un libro sobre los moluscos marinos de Canarias (Hernández, Rolán, Swinnen, Gómez y Pérez, 2011) y, por otra parte, de dos volúmenes dedicados a los moluscos marinos de Andalucía (Gofas, Salas y Moreno, 2011), éstos últimos describiendo e ilustrando más de 1.200 especies. Sería deseable, partiendo de la base de estas magníficas obras, hacer un esfuerzo adicional y completar así una ansiada obra sobre la malacofauna marina española. Entre tanto, pretendemos seguir aportando datos en este sentido con trabajos como el que aquí presentamos.

Un método muy eficaz para obtener una idea aproximada de las especies de moluscos presentes en una zona consiste en estudiar los restos bioclásticos que se acumulan en determinados lugares del fondo o de las playas (Templado, Paulay, Gittenberger y Meyer, 2010). De esta manera, con el simple estudio de una serie de muestras pequeñas (de aproximadamente un kilogramo de sedimentos bioclásticos) repartidas por una zona, se puede obtener un buen número de especies, muchas de ellas difíciles de localizar por otros métodos de muestreo. Un ejemplo de ello lo constituyen los trabajos de Luque y Templado (1981) o de Aartsen, Menkhorst y Gittenberger (1984), que men-

Tabla I. Localización de las ocho muestras estudiadas.
Table I. Location of the eight studied samples.

Localidad	Fondo	Fecha	Coordenadas	Prof. (m)
Puerto Tofiño, Columbrete Grande	arena y rocas	05/2009	39°54'42.57" N - 0°41'15.61" E	-16 m
Escalera de España, Columbrete Grande	al pie de una gran pared rocosa	05/2009	39°53'47.54" N – 0°41'06.89" E	-35 m
Vertiente sur de La Ferrera	sedimentos próximos a rocas con comunidades de algas fotófilas	05/2009	39°53'16.33" N – 0°40'28.68" E.	-22 m
Vertiente norte de La Foradada	fondo detrítico	05/2009	39°52'33.54" N – 0°40'33.30" E.	-22 m
Suroeste de El Carallot	pradera de *Cymodocea nodosa* sobre fondo detrítico y rocas cercanas	05/2009	39°51'06.32" N – 0°40'52.03"E.	-17 m
Pared ext. Columbrete Grande (Fauna 274B)	detritos	07/1996	39°53'55.45" N – 0°41'09.21" E	- 44 m
Cara este del Banco Fidalgo, al sur de La Ferrera (Fauna 277 B1)	detritos	07/1996	39°53'21.56" N – 0°40'38.14" E	- 40 m
Islote Bauza, al noreste de La Ferrera (Fauna 278B12)	detritos	07/1996	39°53'29.93" N – 0°40'39.54" E	-55 m

cionan respectivamente 163 especies de moluscos en un islote de Formentera, o 393 especies en la bahía de Algeciras, respectivamente, en base al examen de unas pocas muestras de arena conchífera explayada.

Por todo lo anterior, hemos decidido abordar el estudio de los moluscos de diversos enclaves insulares españoles a partir del análisis de sedimentos bioclásticos obtenidos a diferentes profundidades y próximos a hábitats diversos. Es también nuestra intención llamar la atención sobre el elevado elenco de especies raras, que son un componente importante de la biodiversidad y tienen una notable importancia desde los puntos de vista de la biología evolutiva, de la ecología y de la conservación (LIM, BALKE AND MEIER, 2012). Bajo esta perspectiva, en el presente trabajo presentamos los resultados del estudio de varias muestras de sedimento bioclástico de las islas Columbretes referentes a los gasterópodos, para completar así los listados anteriores aportados por ACUÑA (1980), ACUÑA, MUÑOZ, PUIG, RUBIO, BORONAT, FRESNEDA Y GARCÍA FLOR (1998) y TEMPLADO, CALVO, GARCÍA CARRASCOSA, BOISSET Y JIMÉNEZ (2002).

MATERIAL Y MÉTODOS

El presente trabajo se ha basado en el estudio de 8 muestras de sedimentos bioclásticos (de entre medio litro y litro y medio), recogidas mediante buceo con escafandra autónoma (tres de ellas recogidas durante la campaña Fauna IV en junio de 1996 y las otras cinco en mayo de 2009; Tabla I). Dichos sedimentos, una vez secados y cribados, fueron analizados mediante una lupa binocular. Las muestras proceden de diversos puntos de la Reserva Marina de las islas Columbretes, pequeños islotes volcánicos situados lejos de la costa a unas 30 millas náuticas de las costas de Castellón (Este de España), entre las coordenadas 39° 51'-39° 55' N y 0° 40' - 0° 42' E. Una descripción detallada de las características de este archipiélago y de las comunidades bentónicas presentes en su entorno puede verse en el libro de TEMPLADO *ET AL.* (2002), así como una lista completa de las

especies marinas citadas o encontradas hasta la fecha en sus fondos.

Las muestras se han recogido en diversos puntos repartidos por el archipiélago en un rango batimétrico de entre 16 y 55 m. El objetivo de estas muestras era meramente cualitativo y no cuantitativo, por lo que se perseguía exclusivamente recoger el mayor número posible de especies. Por eso, se seleccionaron lugares donde hubiera una importante acumulación de bioclastos, al pie de grandes paredes rocosas, que se extendían desde la parte emergida hasta más de 20-25 m, o en zonas de confluencia de hábitats diversos (algas fotófilas, enclaves esciáfilos, detríticos o praderas de *Cymodocea nodosa*). Ello explica, por ejemplo, que en muestras recogidas a más de 20 m de profundidad aparecieran especies propias del supralitoral, como litorínidos. Por tanto, no es posible a partir de estas muestras hacer discriminaciones sobre la distribución de especies por hábitats.

También se han incluido en los resultados del presente trabajo algunas especies observadas directamente durante las inmersiones y no citadas con anterioridad en el archipiélago, aunque no aparecieran en las muestras estudias. El material en buen estado, o aquel que por su rareza fuera interesante conservar, se ha depositado en la colección de malacología del Museo Nacional de Ciencias Naturales de Madrid (MNCN). Para el estudio comparativo de algunos taxones se ha utilizado material depositado en esta misma colección, así como material cedido por Emilio Rolán, Anselmo Peñas y Serge Gofas. La nomenclatura seguida se ha adecuado a la de la base de datos CLEMAM.

Algunos ejemplares se seleccionaron para su estudio con el microscopio electrónico de barrido (SEM) FEI INSPECT y FEI QUANTA (5350 NE Dawson Creek Drive Hillsboro Oregon 97124 USA) del Museo Nacional Ciencias Naturales de Madrid.

RESULTADOS

En la Tabla II se incluye una lista completa de todas las especies de gasterópodos encontradas en las muestras estudiadas en el presente trabajo, en total 251 especies, más 6 especies observadas durante las inmersiones y no citadas previamente en Columbretes. De las 257 especies incluidas en la tabla, 119 no se habían citado con anterioridad en las islas Columbretes (se señalan en la tabla con un asterisco, o con un signo + en el caso de las especies observadas en inmersión) y, además, una de ellas se describe como nueva. De algunas de las especies sólo se han obtenido protoconchas o juveniles, por ejemplo, de los vermétidos.

A continuación se incluyen comentarios sobre varios de los taxones estudiados (aparecen en negrita en la Tabla II) y se describe la especie que consideramos nueva para la ciencia (también resaltada en negrita en la Tabla II).

Comentarios sobre algunos taxones

Género *Dikoleps*

En Columbretes se han encontrado tres especies de *Dikoleps*. Una de ellas, de la que únicamente se ha localizado una concha, presenta la típica superficie escarchada característica de *D. pruinosa (Chaster, 1896)*. Al comparar esta única concha con la ilustrada por Rubio, Dantart y Luque (2004), hemos encontrado ligeras diferencias, lo que unido a que el área de distribución conocida de *D. pruinosa* parece limitarse a la zona del Estrecho de Gibraltar, hemos preferido referirnos a ella como *D.* cf. *pruinosa* (figs. 1-5). Su protoconcha pauciespiral sugiere una limitada capacidad de dispersión de esta especie. En tanto no se

Tabla II. Lista de las especies de gasterópodos encontradas en las muestras estudiadas (en negrita se señalan los taxones que son comentados en el texto y con un asterisco se indican aquellas especies que se citan por primera vez en las islas Columbretes; con un signo + se indican algunas especies no encontradas en las muestras, pero observadas directamente en las inmersiones y que no se habían citado previamente en el archipiélago).

Table II. List of species of gastropods found in the studied samples (taxa that are discussed in the text are indicated in boldface, an asterisk indicates those species recorded for the first time in Columbretes islands; + denotes some species not collected in the samples, but observed directly during the dives and which had not been cited previously in the archipelago).

Familia LOTTIIDAE
Tectura virginea (Müller O.F., 1776)
Familia NERITIDAE
Smaragdia viridis (Linnaeus, 1758)
Familia FISSURELLIDAE
Diodora gibberula (Lamarck, 1822)
Diodora graeca (Linnaeus , 1758)
Emarginula huzardii (Payraudeau , 1826)
**Emarginula octaviana* Coen, 1939
**Emarginula sicula* Gray, 1825
**Emarginula tenera* Locard, 1892
Fissurella nubecula (Linnaeus, 1758)
Familia SCISSURELLIDAE
Sinezona cingulata (Costa, O.G., 1861)
Scissurella costata D'Orbigny ,1824
Familia HALIOTIDAE
Haliotis tuberculata lamellosa Lamarck, 1822
Familia CALLIOSTOMATIDAE
Calliostoma conulus (Linnaeus, 1758)
Calliostoma laugieri (Payraudeau, 1826)
Familia TROCHIDAE
Clanculus cruciatus (Linnaeus, 1758)
Clanculus jussieui (Payraudeau, 1826)
**Gibbula ardens* (von Salis, 1793)
Gibbula drepanensis (Brugnone, 1873)
**Gibbula fanulum* (Gmelin, 1791)
Gibbula guttadauroi (Philippi, 1836)
**Gibbula magus* (Linnaeus, 1758)
Gibbula racketti (Payraudeau, 1826)
Gibbula turbinoides (Deshayes, 1835)
Jujubinus exasperatus (Pennant, 1777)
Jujubinus gravinae (Dautzenberg, 1881)
Jujubinus cf. *striatus* (Linnaeus, 1758)
Jujubinus montagui (W. Wood, 1828)
Osilinus turbinatus (Born, 1778)
Familia TURBINIDAE
Bolma rugosa (Linnaeus, 1767)
Dikoleps cf. pruinosa (Chaster, 1896)
Dikoleps cf. rolani Rubio, Dantart y Luque, 1998
Dikoleps cf. templadoi Rubio, Dantart y Luque, 2004
Familia PHASIANELLIDAE
Tricolia tenuis (Michaud , 1828)
Familia TURRITELLIDAE
**Turritella communis* Risso, 1826
Turritella turbona Monterosato, 1877
Familia SILIQUARIIDAE
**Petalopoma elisabettae* Schiaparelli, 2002
Familia CERITHIIDAE
Bittium latreillei (Payraudeau, 1826)
Bittium reticulatum (Da Costa, 1778)
**Bittium submammillatum* (Rayvenal y Ponzi, 1854)
Cerithium lividulum Risso, 1826
Cerithium vulgatum Bruguière, 1792
Cerithium protractum Bivona Ant. in Bivona And., 1838
Familia PLANAXIDAE
**Fossarus ambiguus* (Linnaeus, 1758)
Familia LITTORINIDAE
Melaraphe neritoides (Linnaeus, 1758)
Echinolittorina punctata (Gmelin, 1791)
Familia CINGULOPSIDAE
Eatonina pumila (Monterosato, 1884)
Familia ASSIMINEIDAE
**Paludinella littorina* (Delle Chiaje, 1828)
Familia CAECIDAE
Caecum auriculatum de Folin, 1868
Caecum subannulatum de Folin, 1870
Caecum trachea (Montagu, 1803)
Familia IRAVADIIDAE
**Hyala vitrea* (Montagu,1803)
Familia RISSOIDAE
Alvania balearica Oliver y Templado, 2009
Alvania beanii (Hanley in Thorpe, 1844)
Alvania cancellata (da Costa, 1778)
Alvania carinata (da Costa, 1778)
Alvania cimex (Linnaeus, 1758)
Alvania geryonia (Nardo, 1847)
Alvania lanciae (Calcara, 1845)
Alvania lineata Risso, 1826
Alvania punctura (Montagu, 1803)
Alvania scabra (Philippi, 1844)
Alvania tessellata Weinkauff, 1868
**Alvania zetlandica* (Montagu, 1815)
***Crisilla ramosorum* n. sp.**
Crisilla semistriata (Montagu, 1808)

Tabla II. Conrinuación.
Table II. Continuation.

Manzonia crassa (Kanmacher, 1798)
**Obtusella intersecta* (Wood S. W., 1857)
Pusillina philippi (Aradas & Maggiore, 1844)
Pusillina inconspicua (Alder, 1844)
**Rissoa guerinii* Récluz, 1843
**Rissoa similis* Scacchi, 1836
Rissoa variabilis (Megerle von Mühlfeldt, 1824)
Rissoa ventricosa Desmarest, 1814
**Rissoa violacea* Desmarest, 1814
Rissoina bruguieri (Payraudeau, 1826)
Familia ANABATHRIDAE
**Pisinna glabrata* (Megerle von Mühfeld, 1824)
Familia CALYPTRAEIDAE
Calyptraea chinensis (Linnaeus, 1758)
Familia CAPULIDAE
Capulus ungaricus (Linnaeus, 1758)
Familia VERMETIDAE
Dendropoma petraeum (Monterosato, 1884)
Vermetus triquetrus Bivona Ant., 1832
**Vermetus granulatus* (Gravenhorst, 1831)
Serpulorbis arenaria (Linnaeus, 1758)
Familia OVULIDAE
Simnia spelta (Linnaeus, 1758)
Pseudosimnia carnea (Pioret, 1789)
Familia VELUTINIDAE
Lamellaria perspicua (Linnaeus, 1758)
Familia TRIVIIDAE
Erato voluta (Montagu, 1803)
Trivia arctica (Solander in Humphrey, 1797)
**Trivia monacha* (Da Costa, 1778)
**Trivia pulex* (Solander, 1828)
Familia NATICIDAE
Euspira pulchella (Risso, 1826)
**Notocochlis dillwyni* (Payraudeau, 1826)
Payradeautia intricata (Donovan, 1804)
Familia ATLANTIDAE
Atlanta sp.
**Oxygyrus keraudreni* (Lesueur, 1817)
Familia CERITHIOPSIDAE
**Cerithiopsis annae* Cecalupo y Buzzurro, 2005
Cerithiopsis* cf. *barleei Jeffreys, 1867
Cerithiopsis* cf. *micalii Cecalupo y Villari,1997
Cerithiopsis* cf. *tubercularis (Montagu, 1803)
**Cerithiopsis* cf. *buzzurroi* Cecalupo y Robba, 1010
**Cerithiopsis* cf. *denticulata* Cecalupo y Robba, 1010
**Cerithiopsis fayalensis* Watson, 1880
**Cerithiopsis jeffreyssi* Watson, 1885
**Cerithiopsis ladae* Prki y Buzzurro, 2007
Cerithiopsis minima (Brusina, 1865)
Cerithiopsis nana Jeffreys, 1867
Cerithiopsis scalaris Locard, 1892
Cerithiopsis sp.1
Cerithiopsis sp.2
**Dizoniopsis coppolae* (Aradas, 1870)
Dizoniopsis sp.
**Krachia cylindrata* (Monterosato, 1874)
Familia TRIPHORIDAE
**Obesula marisnostris* Bouchet, 1895
Cheirodonta pallescens (Jeffreys, 1867)
Marshallora adversa (Montagu, 1803)
Metaxia metaxae (delle Chiaje, 1828)
Monophorus erythrosoma (Bouchet y Guillemot, 1978)
Monophorus perversus (Linnaeus, 1758)
**Monophorus thiriotae* Bouchet, 1985
**Similiphora similior* (Bouchet y Guillemot, 1978)
Familia EPITONIIDAE
**Epitonium algerianum* (Weinkauff, 1866)
**Epitonium clathrus* (Linnaeus, 1758)
**Epitonium pulchellum* (Bivona Ant., 1832)
Gyroscala lamellosa (Lamarck, 1822)
**Opalia hellenica* (Forbes, 1844)
Familia EULIMIDAE
**Melanella boscii* (Payraudeau, 1826)
**Melanella petitiana* (Brusina, 1869)
Parvioris ibizenca (Nordsieck, 1968)
Sticteulima jeffreysiana (Brusina, 1869)
Vitreolina curva (Monterosato, 1874)
Vitreolina philippi (de Rayvenal y Ponzi, 1854)
Vitreolina cf. incurva (Bucquoy, Dautzenberg y Ponzi 1854)
**Vitreolina perminima* (Jeffreys, 1884)
**Curveulima devians* (Monterosato, 1884)
Familia PTEROTRACHEIDAE
**Firoloida desmarestia* Lesueur, 1817
Familia MURICIDAE
+*Babelomurex cariniferus* (Sowerby, 1834)
**Dermomurex scalaroides* (de Blainville, 1829)
Muricopsis cristata (Brocchi, 1814)
Muricopsis aradasii (Poirier, 1883)
Ocenebra erinaceus (Linnaeus, 1758)
Ocinebrina aciculata (Lamarck, 1822)
Ocinebrina edwarsii (Payraudeau, 1826)
Trophonopsis muricata (Montagu, 1803)
Coralliophila meyendorphii (Calacara, 1845)
**Coralliophila panormitana* (Monterosato, 1869)
Familia BUCCINIDAE
Chauvetia* cf. *turritellata (Deshayes, 1835)

Tabla II. Conrinuación.
Table II. Continuation.

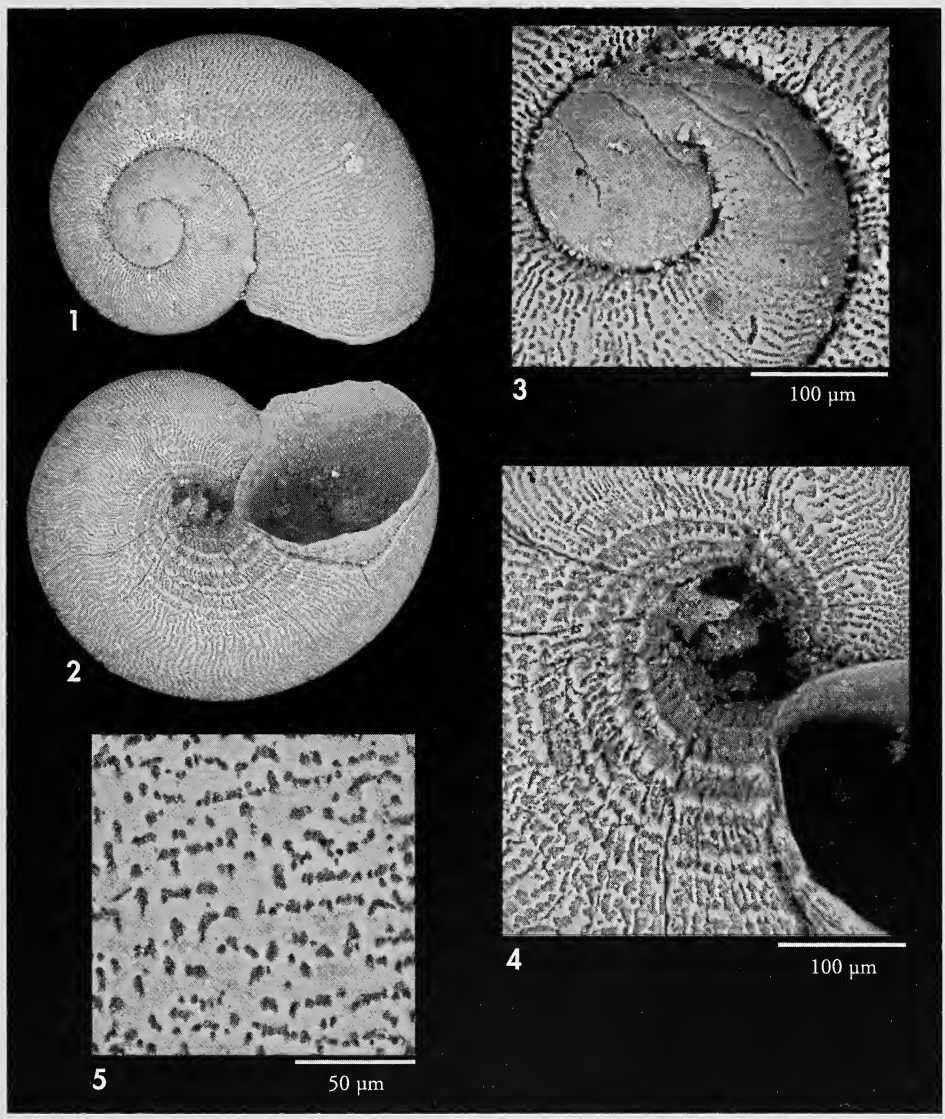
Chauvetia lineolata (Tiberi, 1868)
Chauvetia mamillata (Risso,1826)
****Chauvetia procerula*** (Monterosato, 1889)
****Chauvetia recondita*** (Brugnone, 1873)
Pisania striata (Gmelin, 1791)
Pollia dorbigny (Payraudeau, 1826)
**Pollia scabra* Locard, 1892
Familia COLUMBELLIDAE
Columbella rustica (Linnaeus , 1758)
Mitrella scripta (Linnaeus, 1758)
Mitrella gervillii (Payraudeau, 1826)
**Mitrella minor* (Scacchi, 1836)
Familia NASSARIIDAE
Nassarius cuvierii (Payraudeau, 1826)
Nassarius incrassatus (Ström, 1768)
Familia FASCIOLARIIDAE
Fusinus pulchellus (Philippi, 1844)
Familia CYSTISCIDAE
**Gibberula caelata* (Monterosato, 1877)
Gibberula cf. miliaria (Linnaues, 1758)
Gibberula philippi (Monterosato, 1878)
Familia MARGINELLIDAE
**Granulina marginata* (Bivona Ant., 1832)
Granulina occulta (Monterosato, 1869)
Familia MITRIDAE
+ *Mitra cornea* Lamarck, 1811
Mitra cornicula (Linnaeus, 1758)
Familia COSTELLARIIDAE
Vexillum ebenus (Lamarck, 1811)
Vexillum tricolor (Gmelin, 1791)
Familia TURRIDAE
Haedropleura septangularis (Montagu, 1803)
Familia CONIDAE
Conus mediterraneus Hwass in Bruguière, 1792
**Drilliola loprestiana* (Calcara, 1841)
Mangellia multilineolata (Deshayes, 1835)
**Mangellia stossiciana* Brusina, 1869
**Mangellia taeniata* (Deshayes, 1835)
**Mangellia unifasciata* (Deshayes, 1835)
**Mangellia vauquelini* (Payraudeau, 1826)
**Mitromorpha mediterranea* Mifsud, 2001
**Raphitoma* cf. *intermedia*. Nordsieck, 1968
**Raphitoma atropurpurea* (Locard y Caziot, 1900)
Raphitoma bicolor (Risso, 1826)
**Raphitoma concinna* (Scacchi, 1836)
**Raphitoma echinata* (Brocchi, 1814)
Raphitoma leufroyi (Michaud, 1828)
Raphitoma linearis (Montagu, 1803)
**Raphitoma lineolata* (Bucquoy, Dautzenberg y Dollfus, 1883)
Familia CORNIROSTRIDAE
**Tomura depressa* (Granata-Grillo, 1877)
Familia ARCHITECTONICIDAE
**Pseudotorinia architae* (Costa O.G. , 1841)
Familia CIMIDAE
****Cima cilyndrica*** (Jeffreys, 1856)
****Cima* cf. *minima*** (Jeffreys, 1858)
Familia OMALOGYRIDAE
Ammonicera fischeriana (Monterosato, 1869)
****Ammonicera rota*** (Forbes y Hanley, 1850)
***Ammonicera* sp. 1**
***Ammonicera* sp. 2**
Omalogyra atomus (Philippi, 1841)
****Omalogyra simplex*** (Costa O.G., 1861)
Omalogyra* cf. *simplex (Costa O.G., 1861)
****Retrotortina fuscata*** Chaster, 1896
***Retrotortina* sp.**
Familia RISSOELLIDAE
Rissoella diaphana (Alder, 1848)
Familia HYALOGIRINIDAE
****Hyalogyra zibrowii*** Waren in Waren, Carrozza y Rochini, 1997
Familia MURCHISONELLIDAE
**Ebala gradata* (Monterosato, 1848)
**Ebala nitidissima* (Montagu, 1803)
Ebala pointeli (de Folin, 1868)
Familia AMATHINIDAE
**Clathrella clathrata* (Philippi, 1844)
Familia PYRAMIDELLIDAE
**Chrysallida cf. interstincta* (J. Adams, 1797)
**Chrysallida clathrata* (Jeffreys, 1848)
**Chrysallida decussata* (Montagu, 1803)
**Chrysallida emaciata* (Brusina, 1866)
Chrysallida excavata (Philippi, 1836)
**Chrysallida incerta* (Milaschewitsch, 1916)
**Chrysallida indistincta* (Montagu, 1808)
**Chrysallida intermixta* (Monterosato, 1884)
**Chrysallida interstincta* (J. Adams, 1797)
**Chrysallida jeffreyssiana* (Monterosato, 1844)
Chrysallida suturalis (Philippi, 1844)
**Chrysallida terebellum* (Philippi, 1844)
**Eulimella acicula* (Philippi, 1836)
**Eulimella cossignaniorum* van Aartsen, 1995
**Odostomella bicincta* (Tiberi, 1868)
Odostomella doliolum (Philippi, 1844)
Odostomia acuta Jeffreys, 1848
**Odostomia carrozzai* Van Aartsen, 1987
**Odostomia conspicua* Alder, 1850

Tabla II. Conrinuación.
Table II. Continuation.

**Odostomia eulimoides* Hanley, 1844	**Haminoea navicula* (da Costa, 1778)
Odostomia lukisi Jeffreys, 1859	*Weinkauffia turgidula* (Forbes, 1844)
Odostomia scalaris McGillivray, 1843	Familia PHILINIDAE
**Odostomia striolata* Forbes y Hanley, 1850	**Philine angulata* Jeffreys, 1867
Odostomia turrita Hanley, 1844	**Philine catena* (Montagu,1803)
**Odostomia unidentata* (Montagu, 1803)	**Philine intricata* Monterosato, 1884
**Ondina dilucida* (Monterosato, 1844)	Familia PERACLIDAE
**Ondina warreni* (Thompson, 1845)	**Peracle reticulata* (d'Orbigny, 1836)
**Turbonilla jeffreysii* (Forbes y Hanley, 1850)	Familia CAVOLINIIDAE
**Turbonilla gradata* Bucquoy, Dautzenberg y Dollfus, 1883	**Cavolinia inflexa* (Lesueur,1813)
**Turbonilla pusilla* (Philippi, 1844)	**Creseis acicula* Rang, 1828
**Turbonilla striatula* (Linneo, 1758)	**Styliola subula* (Quoy y Gaimard, 1827)
Familia RETUSIDAE	Familia LIMACINIDAE
**Cylichnina umbilicata (*Montagu, 1803)	**Limacina inflata* (d'Orbigny, 1836)
Retusa mamillata (Philippi, 1836)	Familia PLEUROBRANCHIDAE
**Retusa minutissima* Monterosato (1878)	+*Pleurobranchus testudinarius* Cantraine, 1835
Retusa truncatula (Bruguiere, 1792)	+*Berthella plumula* (Montagu, 1803)
Familia RINGICULIDAE	Familia FACELINIDAE
**Ringicula conformis* Monterosato, 1877	+*Facelina rubrovittata* (Costa, A., 1866)
Familia BULLIDAE	Familia AEOLIDIIDAE
**Bulla striata* Bruguiere,1792	+*Spurilla neapolitana* (delle Chiaje, 1844)
Familia HAMINOEIDAE	Familia SIPHONARIIDAE
Haminoea hydatis (Linnaeus, 1758)	**Williamia gussonii* (Costa O.G. ,1829)

comparen más ejemplares y se estudien las partes blandas del animal, no se podrá concluir si se trata o no de la misma especie del Estrecho.

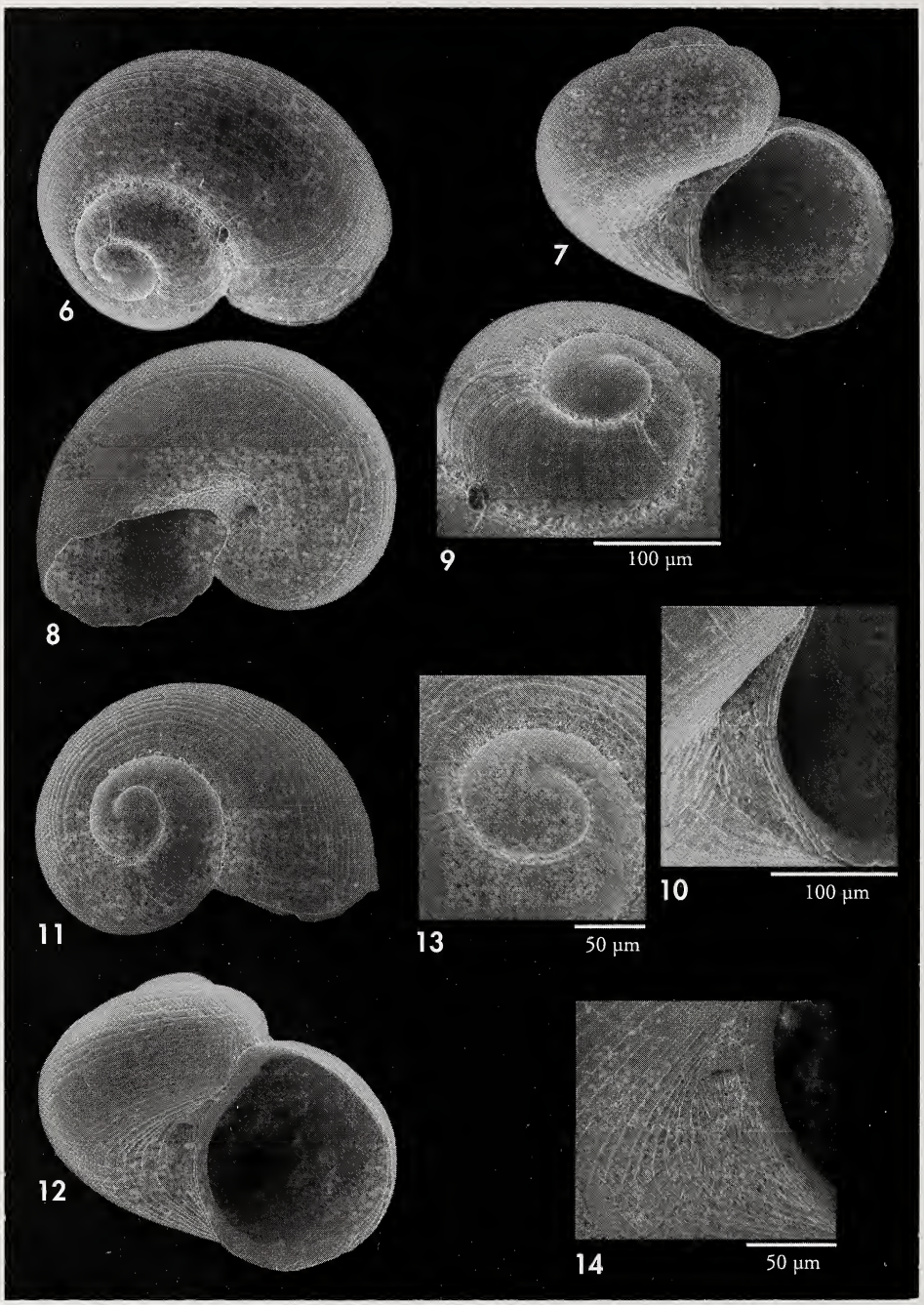
De las otras dos especies de *Dikoleps*, una está ornamentada con surcos espirales, por lo que pertenece al grupo de *D. cutleriana* (Clark, 1848), *D. marianae* Rubio, Dantart y Luque, 1998 y *D. rolani* Rubio, Dantart y Luque, 1998, y la otra ornamentada con cordones en el ombligo y con incisiones punctiformes en la teleoconcha, por lo que se relaciona con *D. nitens* (Philipp, 1844), *D. umbilicostriata* (Gaglini, 1987) y *D. templadoi* Rubio, Dantart y Luque, 2004. Rubio Salazar (1990) señala la presencia de *D. cutleriana* y *D. nitens* en Columbretes, pero posteriormente Rubio *et al.* (1998 y 2004) revisan dichos taxones y describen nuevas especies ibéricas del género (*D. marianae, D. rolani* y *D. templadoi*), además de incluir como perteneciente a la fauna ibérica también a *D. umbilicostriata*. Estos autores concluyen que *D. cutleriana* y *D. nitens* son especies atlánticas que no están presentes en el Mediterráneo. Por lo tanto, la verdadera identidad de las especies de *Dikoleps* de Columbretes estaría por determinar. Asimismo, Rubio *et al.* (1998 y 2004) señalan que *D. marianae* y *D. templadoi* están presentes en Baleares y *D. rolani* en la Costa Brava, por lo que serían las especies que, en principio, podrían estar presentes en Columbretes, sin descartar a *D. umbilicostriata*, presente en el mar de Alborán. Sin embargo, el estudio detallado de las conchas halladas por nosotros en Columbretes no ha permitido asignarlas con seguridad a ninguno de los taxones anteriores. Así pues, pendientes de posteriores estudios que puedan determinar si se trata o no de especies nuevas, posiblemente



Figuras 1-5. *Dikopleps* cf. *pruinosa*. 1-2: concha (0,8 mm de diámetro); 3: protoconcha; 4: detalle de la escultura umbilical; 5: detalle de la microescultura.
Figures 1-5. Dikopleps cf. pruinosa. *1-2: shell (0.8 mm in diameter); 3: protoconch; 4: detail of the umbilical sculpture; 5: detail of the microsculpture.*

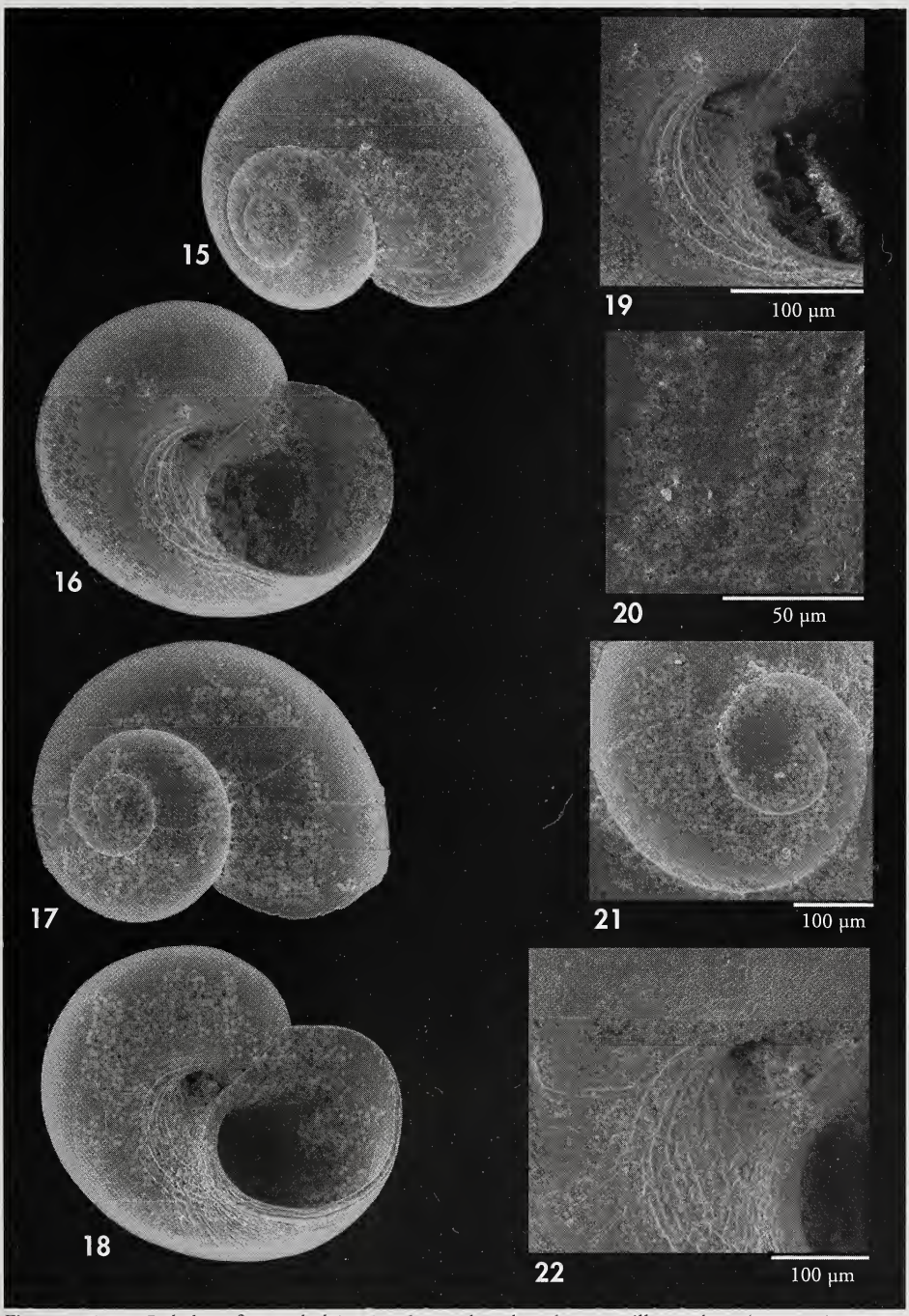
endémicas, o simples variedades, las hemos determinado como *Dikoleps* cf. *rolani* (figs. 6-14) y *Dikoleps* cf. *templadoi* (figs. 15-22).

Dikoleps cf. *rolani* muestra cierta variabilidad respecto a sus surcos espirales. Con la lupa binocular en algunas conchas es posible ver claramente los surcos en toda la espira, mientras que en otras sólo se observan con claridad en su parte basal, aunque con el SEM sí se pueden apreciar. Las primeras (figs. 11-12) se parecen más a *D. marianae* (y suelen aparecer en sedimentos recogidos a más profundidad), mientras que las segundas (figs. 6-8) se asemejan más



Figuras 6-14. *Dikoleps* cf. *rolani*. 6-8: conchas (0,88 mm, 0,9 mm y 0,82 mm, respectivamente); 9: detalle de la protoconcha; 10: detalle del ombligo; 11, 12: conchas de aguas más profundas con la escultura más patente (0,8 mm y 0,87 mm, respectivamente); 13: detalle de la protoconcha; 14: detalle del ombligo.

Figures 6-14. Dikoleps cf. rolani. *6-8: shells (0.88 mm, 0.9 mm y 0.82 mm, respectively); 9: detail of the protoconch; 10: detail of the umbilicus; 11, 12:* shell from deeper bottoms *with the sculpture more evident (0.8 mm y 0.87 mm, respectivamente); 13: detail of the protoconch; 14: detail of the umbilicus.*



Figuras 15-22. *Dikoleps* cf. *templadoi*. 15, 16: conchas de color amarillo verdoso (0,8 mm); 17-18: conchas de color claro (0,8 mm); 19: detalle del ombligo de la concha de la figura 15; 20: detalle de la microescultura; 21: detalle de la protoconcha; 22: detalle del ombligo de la concha de la figura 18.
Figures 15-22. Dikoleps cf. templadoi. *15, 16: shells greenish yellow in colour (0.8 mm); 17-18: lighter coloured shells (0.8 mm); 19: detail of the umbilicus of the shell from figure 15; 20: detail of the microsculpture; 21: detail of the protoconch; 22: detail of the umbilicus of the shell from figure 18.*

a *D. rolani*. El examen de ambas formas parece indicar que corresponden a una única especie y, como su protoconcha no presenta los cordoncillos espirales que tiene *D. marianae*, se ha preferido relacionarla con *D. rolani*. Además, la anchura de los cordones delimitados por los surcos la asemeja más a *D. rolani* que a *D. marianae*. De los ejemplares típicos de *D. rolani* se distingue por presentar los cordones espirales mucho más evidentes, incluidos los del ombligo, y por ser más globosa.

Dikoleps cf. *templadoi* también muestra variabilidad en cuanto al color, ya que existen conchas tanto blanco brillante como verdoso. Estas últimas resultan especialmente crípticas en fondos en los que son frecuentes pequeños cristales de olivino. El estudio con SEM de las conchas parece indicar que son variantes de color y no especies distintas. Esta variación cromática también aparece en *D. templadoi* (al igual que en *D. nitens* y *D. umbilicostriata*), que también presenta incisiones en forma de punto en su concha. No ha sido posible determinar con claridad que estos ejemplares correspondan a *D. templadoi* o a *D. umbilicostriata* (*D. nitens* es una especie atlántica), o que, por el contrario, se trate de otra especie distinta con características que se podrían considerar intermedias entre ambas. De *D. templadoi* se distingue por tener un ombligo más ancho y por presentar cordones espirales más separados, menos gruesos y sin el reborde externo del labio interno. De *D. umbilicostriata* se diferencia por presentar los cordones espirales basales menos evidentes; en su lugar se disponen incisiones puntuales alineadas espiralmente (figs. 20 y 22). Se ha considerado preferible, por razones de proximidad geográfica, referirnos a ella como *D.* cf. *templadoi*.

Cerithium protractum (Bivona, 1838)

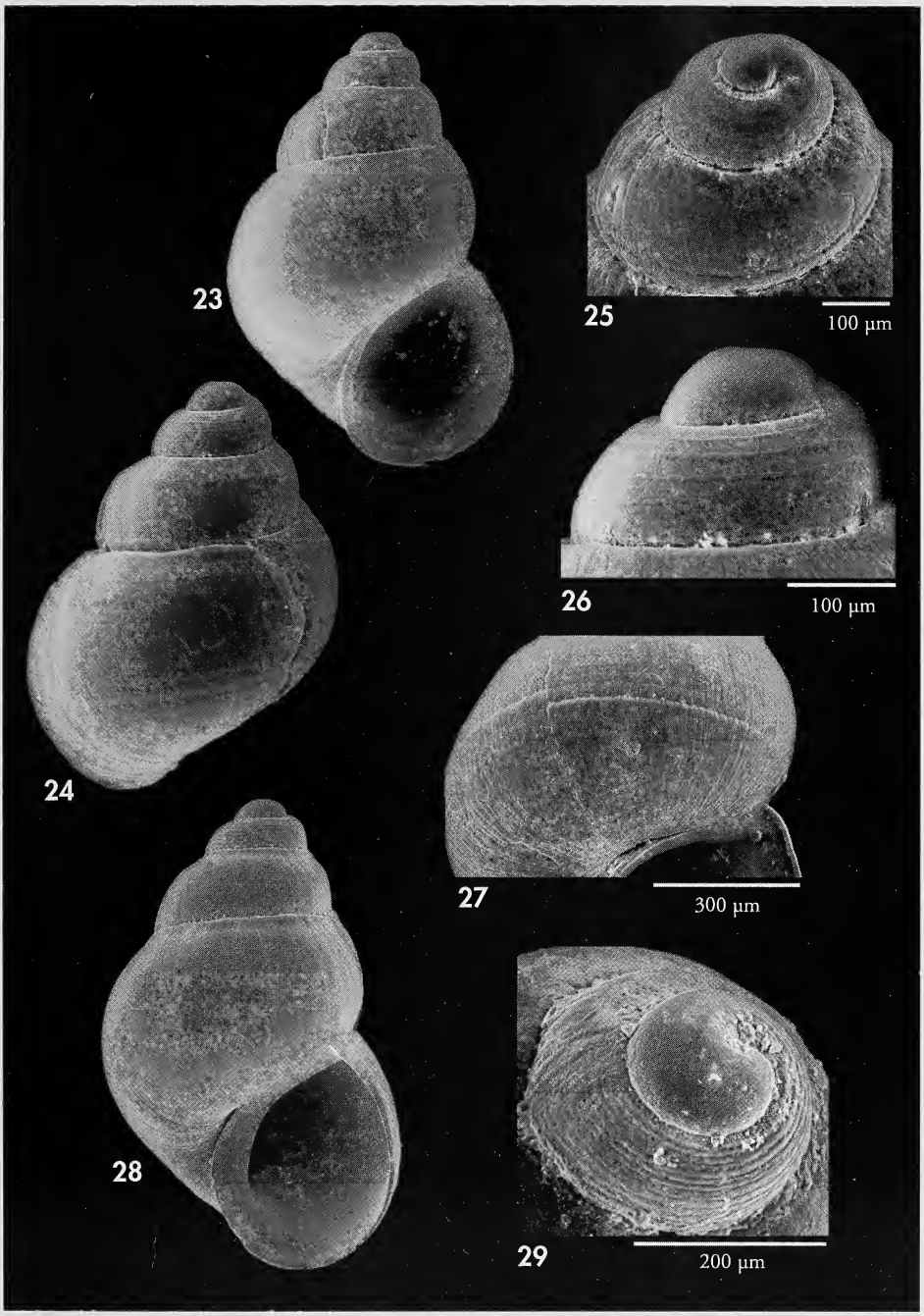
Esta especie ha sido considerada a menudo como sinónimo de *C. vulgatum* Bruguière, 1792, pero recientemente Tarruellas y Lopez (2006) señalan *C. protactum* como especie independiente en las costas de Tarragona y Gofas *et al.* (2011) en el litoral de Almería y de Málaga. En Columbretes hemos encontrado una concha adulta y algunos fragmentos y juveniles.

Género *Crisilla*

En Columbretes hemos encontrado dos especies de risóidos pertenecientes al género *Crisilla*. Una de ellas, *Crisilla semistriata* (Montagu, 1808), es muy común y bien conocida. En cambio, la segunda especie no se ajustaba a las características de las especies conocidas de este género presentes en la fauna española, europea o macaronésica. Por ello, hemos optado por describirla como nueva para la ciencia.

Crisilla ramosorum spec. nov. (Figs. 23-29)

Material tipo: holotipo (fig. 23) y 2 paratipos depositados en el MNCN (nº de catálogo15.05/60050).
Otro material estudiado: islas Columbretes: 45 conchas (Col. J.D. Oliver); Menorca (islas Baleares): 5 conchas (Col. J.D. Oliver); Cabo de Palos (Murcia): 50 conchas (Col. J.D. Oliver); Rodalquilar (Almería): 4 conchas (Col. S. Gofas).
Localidad tipo: Puerto Tofiño (39º 53′ 43″ N – 0º 41′ 15″ E), islas Columbretes, 16 m de profundidad.
Etimología: Dedicada *ex aequo* a Alfonso Ramos Esplá, de la Universidad de Alicante, que animó y orientó al primer autor hacia el campo de la Malacología, y a Marian Ramos, Investigadora Principal del Proyecto Fauna Ibérica.



Figuras 23-29. *Crisilla ramosorum* n. sp. 23: holotipo (1,2 mm); 24: concha (0,99 mm); 25, 26: vistas de la protoconcha del holotipo; 27: detalle de la escultura del holotipo. Figuras 28, 29. *Crisilla aartseni*, Algeciras; 28: concha (1,4 mm); 29: protoconcha.
Figures 23-29. Crisilla ramosorum *n. sp. 23: holotype (1.2 mm); 24: shell (0.99 mm); 25, 26: protoconch views of the holotype; 27: detail of the sculpture of the holotype. Figures 28, 29.* Crisilla aartseni, *Algeciras; 28: shell (1.4 mm); 29: protoconch.*

Descripción: Concha que, con tres vueltas, alcanza una altura de 1,3 mm y una anchura de 0,8 mm (fig. 23). La concha es aparentemente lisa, pero con el SEM se observa un reborde subsutural muy débil. En la primera vuelta se apunta un esbozo de cordón situado en el tercio superior de la espira y es el responsable de que el perfil de la espira en la primera vuelta sea levemente angulado (fig. 24). En algunas conchas puede aparecer un débil surco justo por encima de la sutura inferior (fig. 25). En las vueltas siguientes el cordón superior se desvanece y ya no es perceptible. En las conchas bien conservadas se pueden observar con el SEM cordones espirales muy débiles en toda la espira (fig. 24). En la parte basal de ésta, algo por encima y por debajo de la inserción labial, los cordones se hacen más evidentes, aunque débiles, debido a que sus interespacios son aquí algo más anchos y profundos (fig. 27). La concha es transparente, amarillenta, con líneas de manchas rojizas. En la última espira hay cuatro líneas. La inferior se aprecia en la zona umbilical y no es visible en todas las conchas. La protoconcha (fig. 26) tiene una vuelta y media y alcanza 0,28 mm de anchura y 0,18 de altura. Está ornamentada por varios cordoncillos irregulares y discontinuos muy separados entre sí.

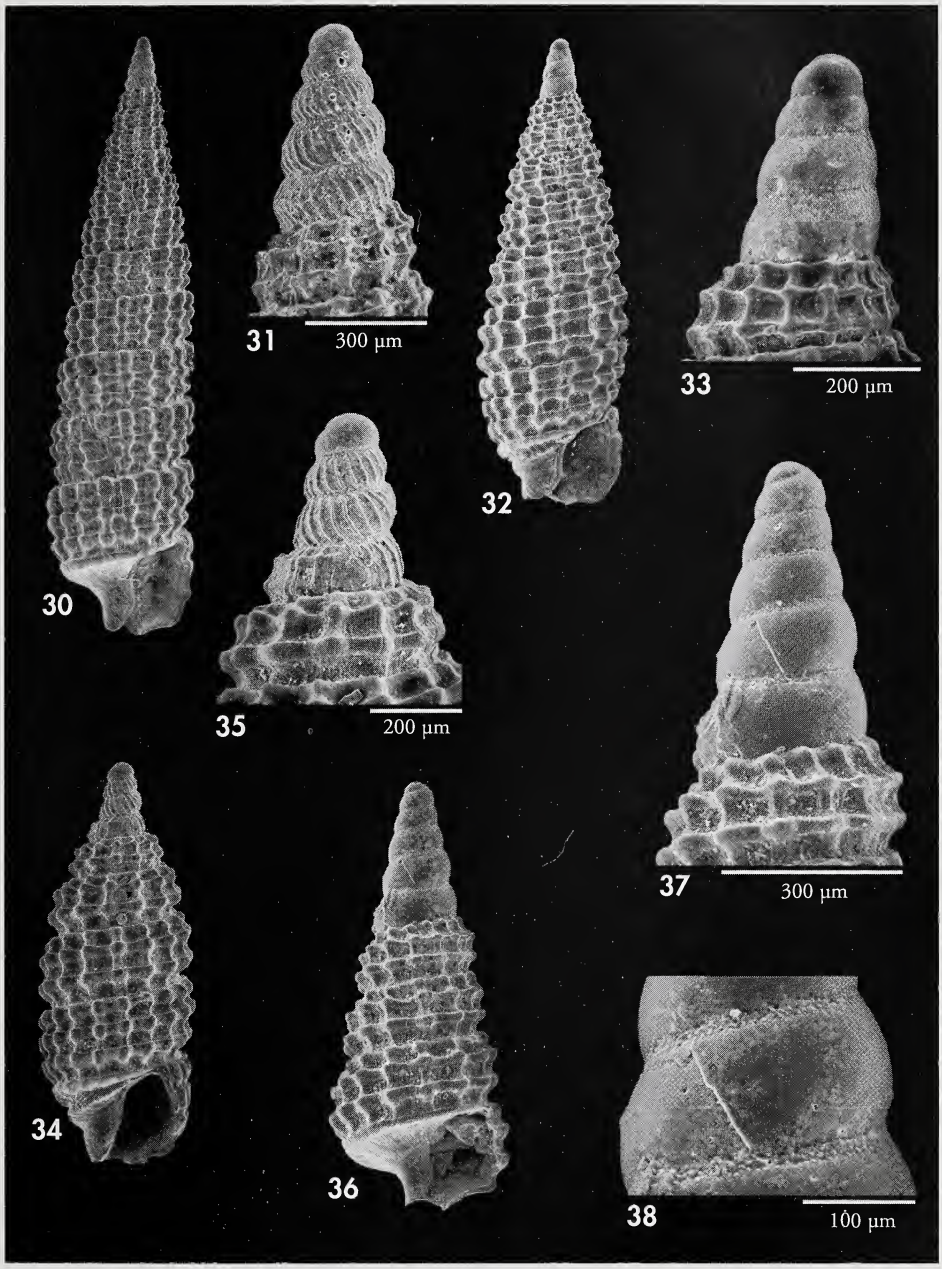
Discusión: Esta especie se halla presente también en Baleares y en el sudeste peninsular. Dada su similitud con *C. aartseni* (Verduin, 1984) (fig. 28), posiblemente se haya confundido con ésta. Las diferencias que nos permiten distinguirlas son: 1) la concha de *C. ramosorum* presenta cordones espirales (fig. 27) que, aunque débiles, son más evidentes que en *C. aartseni*; 2) la sutura de *C. ramosorum* es más profunda, por lo que el perfil de las vueltas es más convexo que en *C. aartseni*; 3) bajo el reborde subsutural de *C. aartseni* se observa una leve depresión que produce cierta concavidad de la espira que no se aprecia (es más recta) en *C. ramosorum*, y 4) la protoconcha de *C. aartseni* presenta unos 14 cordones espirales continuos y apretados (fig. 29), completamente distinta a la de *C. ramosorum* (fig. 26), en la que dichos cordones están más separados. En cuanto a su distribución, *C. aartseni* parece estar restringida a la zona del Estrecho de Gibraltar, mientras que *C. ramosorum* presenta una distribución más amplia, ya que se ha localizado en las islas Columbretes, en las Baleares y en el sureste peninsular.

Por otro lado, la especie *Crisilla chiarelli* (Cecalupo y Quadri, 1995), de Chipre, presenta también débiles cordones longitudinales y un patrón de coloración similar (aunque no idéntico) a la especie de Columbretes. Posiblemente, la ornamentación de la protoconcha también sea parecida, según se deduce del esquema mostrado por los autores de la especie, (Cecalupo y Quadri, 1995), ya que no se muestra una foto al SEM en su descripción original. Sin embargo, las dimensiones de la especie de Chipre son algo mayores que la de Columbretes, la espira es más elevada y, sobre todo, el área de distribución de *C. chiarelli*, una especie al parecer restringida al Mediterráneo oriental y con protoconcha pauciespiral, nos hace descartar que se trate de la misma especie.

Familia Cerithiopsidae

Cerithiopsis cf. *barleei* Jeffreys, 1867 (Figs. 30-31)

En las muestras estudiadas se ha hallado un ejemplar prácticamente adulto con la protoconcha intacta (figs. 30-31), muy similar a la del lectotipo de *Cerithiopsis barleei* Jeffreys, 1867 designado por Ceccalupo y Robba (2010, fig. 2C) a partir de un ejemplar de la colección de Jeffreys (USNM, 62164) procedente de Plymouth. La concha es algo cirtoconoide y alcanza con doce vueltas (sin contar las vueltas de la protoconcha) 5,5 mm. La sutura es algo acanalada, la base es cóncava y se aprecia en su parte superior un único cordón basal



Figuras 30, 31. *Cerithiopsis* cf. *barleei*. 30: concha (5,5 mm); 31: detalla de la protoconcha. Figuras 32, 33. *Cerithiopsis minima*. 32: concha (2,6 mm); 33: detalle de la protoconcha. Figuras 34, 35. *Cerithiopsis* cf. *micali*. 34: concha (1,75 mm); 35: detalle de la protoconcha. Figuras 36-38. *Cerithiopsis* sp.1. 36: concha juvenil (1,5 mm); 37: protoconcha; 38: detalle de la microescultura de la protoconcha.

Figures 30, 31. Cerithiopsis cf. barleei. *30: shell (5.5 mm); 31: detail of the protoconch. Figures 32, 33.* Cerithiopsis minima. *32: shell (2.6 mm); 33: detail of the protoconch. Figures 34, 35.* Cerithiopsis cf. micali. *34: shell (1.75 mm); 35: detail of the protoconch. Figures 36-38.* Cerithiopsis sp.1. *36: juvenile shell (1.5 mm); 37: protoconch; 38: detail of the microsculpture of the protoconch.*

liso. La protoconcha tiene cinco vueltas, la primera granulosa. Luego aparecen finas costillas irregulares, prosoclinas, que no llegan a conectar por su parte superior con la sutura. Entre la parte superior de las costillas y la sutura se pueden observar granulaciones. A pesar de que la escultura de la protoconcha es muy semejante a la del lectotipo de *C. barleei*, la escultura de la teleoconcha parece ser distinta a la de los ejemplares atlánticos de esta especie, que presentan tubérculos más pequeños y redondeados, y se parece más a la de las especies del complejo de *C. scalaris* Locard, 1892. Al no haber llegado a una conclusión clara sobre la identificación de esta especie, hemos preferido referirnos a ella como *C.* cf. *barleei*. Peñas *et al.* (2009, pág. 33 fig. 9) muestran una fotografía de la protoconcha de esta misma especie en las costas catalanas.

Ceccalupo y Robba (2010), siguiendo los criterios taxonómicos de Marshall (1978), que considera que la ornamentación de la protoconcha es suficiente para la separación de géneros, proponen denominar a la especie de Jeffreys *Prolixodens barleei*. Sin embargo, no consideramos adecuado designar nuevos géneros atendiendo únicamente a esos criterios, por lo que hemos preferido seguir manteniendo el género *Cerithiopsis* para las especies con este tipo de protoconcha en tanto no se aporten otros datos diferenciadores (de la teleoconcha, partes blandas del animal, rádula, o moleculares).

Cerithiopsis cf. *micalii* (Cecalupo y Villari, 1996) (Figs. 34-35)

Se han encontrado varios ejemplares que en principio fueron identificados como *C. micalii* (Cecalupo y Villari, 1996), sin embargo, no coinciden exactamente con la descripción original de esta especie. Podría tratarse de una especie no descrita próxima a ésta. Las principales diferencias observadas en los ejemplares de Columbretes son: protoconcha granulada, cordones basales ondulados, aspecto menos cirtoconoide y sutura más ancha (figs. 34 y 35). En cualquier caso, por el momento hemos creído oportuno referirnos a ella como *C.* cf. *micalii*. Las especies identificadas como *Cerithiopsis scalaris* y *Dizoniopsis micali* en el trabajo de Oliver Baldoví (2007, pág. 49, figuras 30-31 y 32-33, respectivamente) podrían corresponder a esta especie de Columbretes.

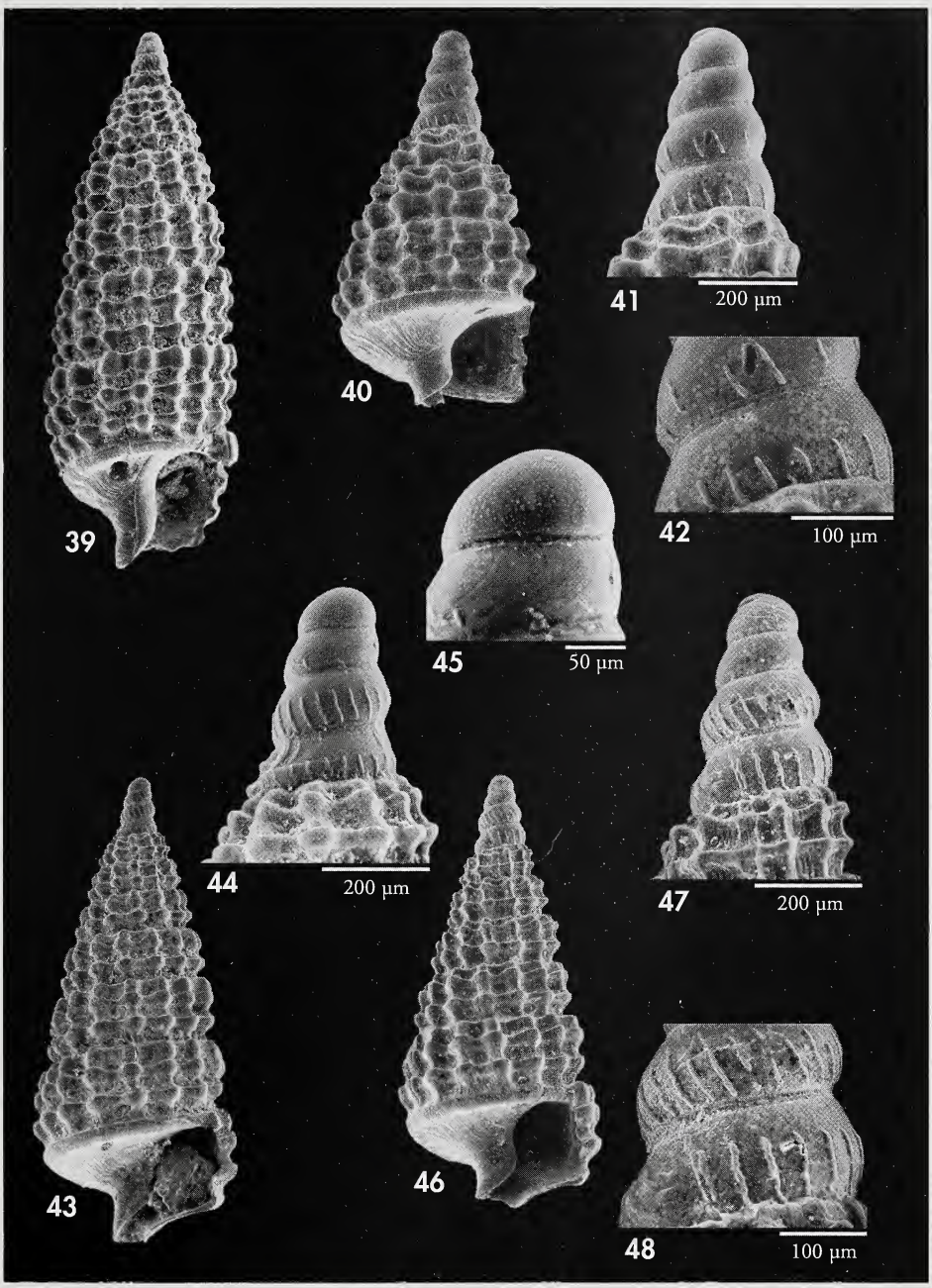
En la descripción original de *C. micalii* Cecalupo y Villari (1996) la asignan al género *Dizoniopsis*. Sin embargo, de acuerdo con Bouchet, Gofas y Waren (2010) creemos que es preferible incluirla dentro de *Cerithiopsis*, debido al tipo de protoconcha que presenta.

Cerithiopsis cf. *tubercularis* (Montagu, 1803)

En las muestras estudiadas hemos encontrado ejemplares adultos cuya teleoconcha se ajusta al tamaño y descripción de *C. tubercularis*. Desafortunadamente, estos ejemplares carecen de protoconcha, por lo que hemos preferido referirnos a ellos como *C.* cf. *tubercularis*. Por otra parte, algunos juveniles presentaban una protoconcha con escultura subsutural granulada, con más vueltas y más puntiaguda (figs. 36-38) que las de *C. tubercularis*, lo que nos hace pensar que corresponderían a una especie distinta, por lo que nos hemos referido a ella como *Cerithiopsis* sp. 1.

Cerithiopsis scalaris Locard, 1892 (Figs. 39-48)

Giribet y Peñas (1997, pág. 67, fig. 26) muestran una fotografía de la protoconcha de un ejemplar procedente de la bahía de Almería. Posteriormente,



Figuras 39-48. *Cerithiopsis scalaris.* 39: concha subadulta (3,1 mm); 40: juvenil (1,3 mm); 41: protoconcha; 42: detalle de la microescultura de la protoconcha; 43: juvenil (2,8 mm); 44: protoconcha; 45: detalle de la protoconcha; 46: juvenil (2,2 mm); 47: protoconcha; 48: detalle de la escultura de la protoconcha.

Figures 39-48. Cerithiopsis scalaris. *39: subadult shell (3.1 mm); 40: juvenile (1.3 mm); 41: protoconch; 42: detail of the microsculpture of the protoconch; 43: juvenile (2.8 mm); 44: protoconcha; 45: detail of the protoconch. 46: juvenile (2.2 mm); 47: protoconcha; 48: detail of the microsculpture of the protoconch.*

Peñas *et al.* (2006) ilustran profusamente esta especie, con detalles de la protoconcha y de su microescultura, a partir de ejemplares procedentes de La Herrradura (Granada) (Peñas *et al.*, 2006, pág. 73, figs. 102 y 104) y de la isla de Alborán (Peñas *et al.*, 2006, pág. 73, figs.103 y105, pág. 75, figs. 110 y 111).

Como en otras especies de *Cerithiopsis*, este taxón probablemente agrupa también varias especies crípticas. La dificultad de encontrar ejemplares adultos con la protoconcha intacta complica la correspondencia entre los juveniles con protoconcha y sus adultos. Así, los juveniles estudiados (figs. 39, 40, 43 y 46) muestran que la teleoconcha puede variar desde cónica a cirtoconoide, con la máxima curvatura más o menos próxima al ápice. Ahora bien, se debería ser prudente en el caso del género *Cerithiopsis* en asignar a una misma especie conchas que difieren en el aspecto de la teleoconcha por mucho que coincida su protoconcha (ver figs. 41, 44 y 47), tal y como se comenta más adelante.

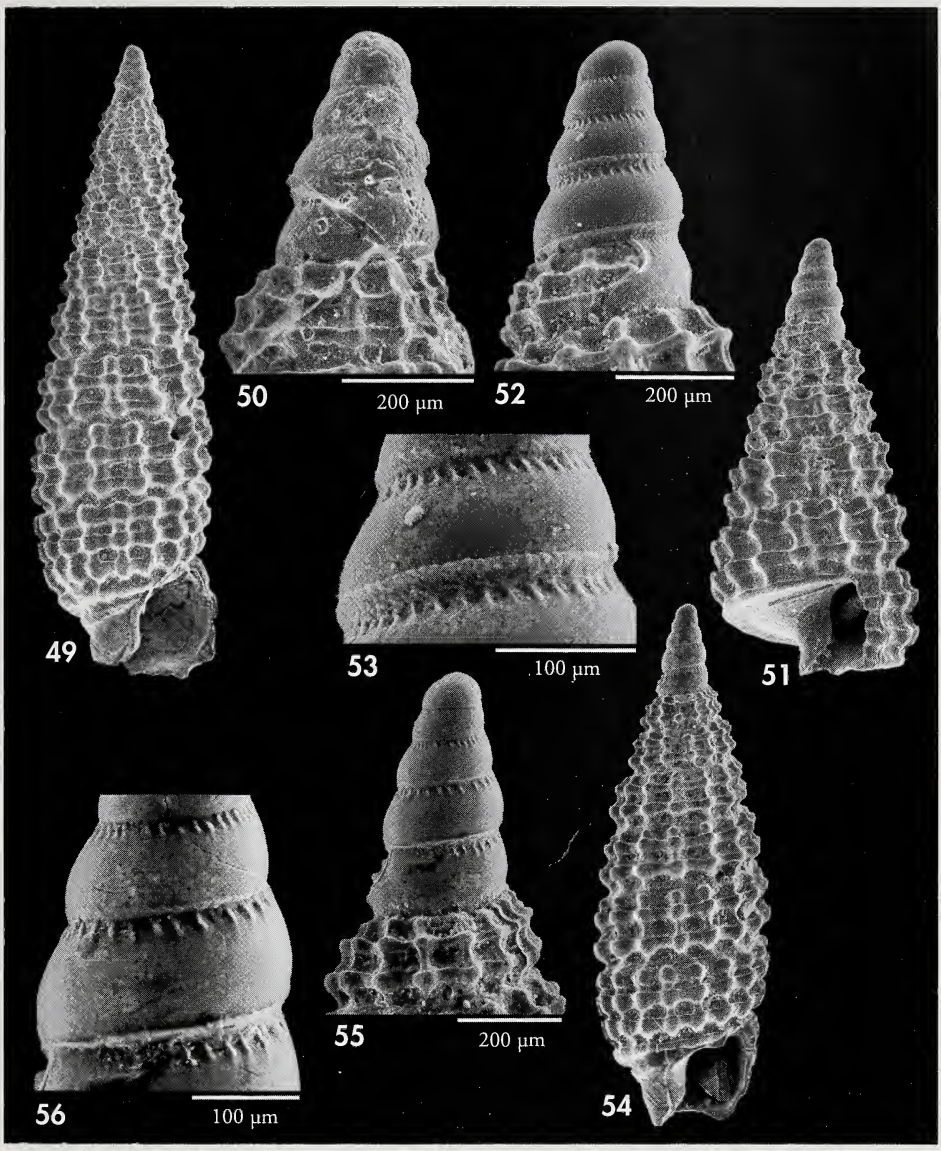
Cerithiopsis nana (Jeffreys, 1867) (Figs. 54-56)

En Columbretes hemos encontrado numerosos ejemplares de esta especie (figs. 54-56), que también está presente en las costas valencianas (Oliver Baldoví, 2007, pág. 47, figs. 17 y 18).

Ceccalupo y Robba (2010) designan como lectotipo un sintipo (USNM 1147923) de la colección de Jeffreys. Aunque estos autores, siguiendo los criterios de Marshall (1978) de considerar con valor genérico la escultura de la protoconcha, proponen el género *Nanopsis* para esta especie y describen dos nuevas especies, *Nanopsis buzzurroi* y *Nanopsis denticulada*. Nosotros creemos más adecuado, por lo apuntado anteriormente, seguir usando para estas especies el nombre genérico de *Cerithiopsis*. En Columbretes hemos encontrado conchas que coinciden con las descripciones de ambas especies, pero que carecen de protoconcha. Como se requiere el estudio de su microescultura para determinarlas correctamente, hemos preferido denominarlas provisionalmente *C.* cf. *buzzurroi* y *C.* cf. *denticulata*, respectivamente.

Por último, una cuarta especie con escultura de protoconcha del tipo de la que presentan las especies del género "*Nanopsis*" (costillas muy finas prosoclinas subsuturales y cordoncillo suprasutural) se halla presente en Columbretes y en el litoral ibérico español (citada como *C. tubercularis* en Peñas *et al.*, 2009, pág. 33, fig. 8). Se ha estudiado un ejemplar adulto de dicha especie (figs. 49 y 50) con la protoconcha deteriorada, en la que apenas se puede apreciar la microescultura (aunque pueden reconocerse algunas finas costillas suturales). Por otra parte, hemos fotografiado un juvenil (figs. 51-53) que podría corresponder a esta especie. Aunque el ejemplar adulto guarda cierto parecido con *C. buzzurroi*, su canal sifonal no es tan apuntado. Por otra parte, la protoconcha (la del juvenil) presenta unos rasgos diferenciadores respecto a *C. buzzurroi* que nos ha llevado a la conclusión de que se trata de una especie distinta que hemos denominado *Cerithiopsis* sp. 2. Tales rasgos son: costillitas prosoclinas más suturales que subsuturales, cordón suprasutural más delimitado y granuloso que en *C. buzzurroi* y sinusoidad más profunda en la transición de la protoconcha con la teleoconcha.

También conviene indicar que Rolán, Espinosa y Fernandez- Garcés (2007) ilustran protoconchas de especies de *Cerithiopsis* de Cuba del tipo de las del género "*Nanopsis*". Es el caso de *C. albovittata* y *C. parvada* (Rolán *et al.*, 2007, pág. 24, figs. 71-75). Aunque las conchas de estas especies (Rolán *et al.*, 2007, pág. 20, figs. 27-40), especialmente la de *C. albovittata*, pueda recordar a *Cerithiopsis* sp. 2, son especies distintas, pero nos ponen de manifiesto que la coincidencia en la protoconcha en los Cerithiopsidae no debe indicar automáticamente que se trate de la misma especie, y más aún si la teleoconcha es distinta.



Figuras 49-53. *Cerithiopsis* sp. 2. 49: concha adulta (3,75 mm); 50: protoconcha; 51: juvenil (1,9 mm); 52: protoconcha; 53: detalle de la microescultura de la protoconcha. Figuras 54-56. *Cerithiopsis nana.* 54: concha adulta (2,7 mm); 55: protoconcha; 56: detalle de la microescultura de la protoconcha.
Figures 49-53. Cerithiopsis sp. 2. *49: adult shell (3.75 mm); 50: protoconch; 51: juvenile (1.9 mm); 52: protoconch; 53:. Figures 54-56.* Cerithiopsis nana. *54: adult shell (2.7 mm); 55: protoconch; 56: detail of the microsculpture of the protoconch.*

Género *Cima*

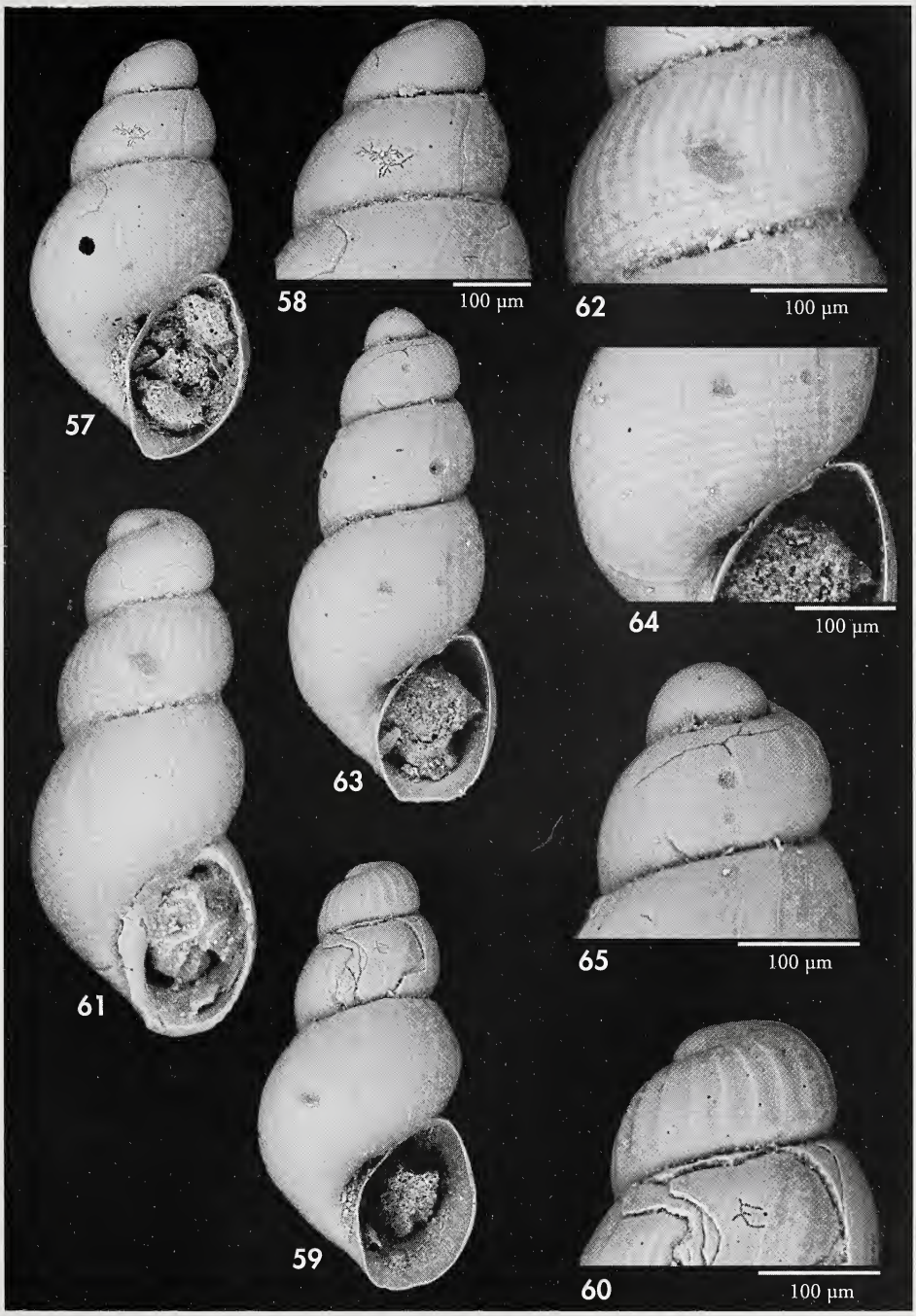
En la base de datos CLEMAM se incluyen seis especies europeas pertenecientes al género *Cima*: *C. cylindrica* (Jeffreys, 1856), *C. minima* (Jeffreys, 1858), *C. cuticulata* Waren, 1993, *C. inconspicua* Waren, 1993, *C. melitensis* Mifsud, 1998 y

C. apicisbelli Rolán, 2003. Se trata de un género de conchas diminutas, no demasiado sólidas y carentes, muchas de ellas, de una ornamentación que pueda ser visible con una lupa binocular. Estas características suelen conducir, por lo general, a infravalorar el número de especies existentes. Prueba de ello es que hasta los años noventa únicamente se consideraban dos especies: *C. minima* y *C. cylindrica* (Aartsen, 1981). Más tarde se describieron *C. cuticulata* y *C. inconspicua* en aguas escandinavas (Waren, 1993), *C. melitensis* en Malta (Mifsud, 1998) y *C. apicisbelli* en la costa de Senegal (Rolán, 2003), aunque esta última también fue encontrada en el Mediterráneo, en el Golfo de Valencia (Oliver Baldoví, 2007) y en Sicilia (Scuderi y Criscione, 2011). Por lo tanto, al menos cuatro especies de *Cima* forman parte de la fauna mediterránea: *C. cylindrica*, *C. minima*, *C. melitensis* y *C. apicisbelli*.

En Columbretes se han encontrado dos especies de este género. Una de ellas, *C. cylindrica*, fue fotografiada con el SEM y descrita con más precisión por Aartsen (1981), a partir de una concha procedente de Ibiza. Este autor indica que aunque algunas conchas pueden aparentar ser lisas, las que están bien preservadas presentan escultura espiral. Las conchas procedentes de Columbretes (figs. 61-65) no sólo presentan una evidente escultura espiral, sino que, además, las líneas sinusoidales de crecimiento, sobre todo en las primeras vueltas, están tan desarrolladas que hacen que la escultura axial sea tan relevante como la espiral. Además, la protoconcha presenta unas débiles costillas axiales sólo visibles en la parte superior de la espira. Las conchas muy esculturadas de *C. cylindrica* y con protoconcha con costillas podrían confundirse con *C. apicisbelli*, pero esta última presenta una protoconcha ornamentada con relevantes cordones longitudinales (ver Scuderi y Criscione, 2011), ausentes en la protoconcha de *C. cylindrica*.

La segunda especie de este género encontrada en el material estudiado, a la que hemos denominado *Cima* cf. *minima*, merece especial discusión. *Cima minima* probáblemente sea la especie más citada del grupo (Albanesi, Cretella, Facente, Fasulo, Ferro, Guarino, Izzillo y Perna, 1981). De esta especie se suele resaltar su forma cónica (aunque variable: relación altura/anchura entre 2 y 2,5 en especímenes de entre 1 y 1,25 mm de altura, según Aartsen, 1981), la ausencia de ornamentación (sólo las líneas de crecimiento) y su protoconcha lisa, globular, prominente y con casi dos vueltas. Las conchas lisas (figs. 57 y 59) que hemos encontrado en Columbretes no parecen tener una protoconcha tan globular o prominente como las fotografiadas por Aartsen (1981), Fretter y Graham (1982) o Waren (1993), todas ellas de procedencia atlántica. Tampoco su protoconcha parece ser totalmente lisa, sino que presenta esbozos de costillas en su parte superior, en general menos evidentes que en *C. cylindrica*. Incluso la protoconcha de una de las conchas lisas encontradas (fig. 60), de alrededor de una vuelta, alcanza 0,19 mm de anchura y 0,10 mm de altura, está ornamentada con costillas axiales planas, tan anchas como sus interespacios, que desaparecen poco antes de llegar a la sutura. Este tipo de escultura ya aparece en un ejemplar de *Cima minima* de la Ría de Vigo (Rolán, 1983, pág. 192, fig. 158). Aunque las protoconchas de los especimenes lisos parecen muy distintas, no se observan otros rasgos que permitan establecer que nos encontremos ante dos especies diferentes. Esta misma situación la hemos observado en conchas procedentes de las islas Chafarinas, enclave en el que se han estudiado más conchas y que parecen apuntar a que nos encontramos ante una especie variable tanto en su aspecto, más o menos cilíndrico, como en la escultura de la protoconcha, más o menos pronunciada.

Otras cuestión es si esta especie corresponde a *C. minima* (Jeffreys, 1858) o a la que aparece fotografiada por Warén (1993), ambas atlánticas y con una protoconcha aparentemente distinta. En tanto no se revise el material tipo o puedan compararse distintas poblaciones, se ha considerado más prudente referirnos de momento a la especie encontrada en Columbretes como *Cima* cf. *minima*.



Figuras 57-60. *Cima* cf. *minima*. 57: concha (0,82 mm); 58: vista de la protoconcha. 59: concha (0,79 mm); 60: protoconcha. Figuras 61-65: *Cima cylindrica*. 61 y 63: conchas (0,65 mm y 0,75 mm, respectivamente); 62 y 64: detalles de la microescultura de la concha; 65: protoconcha de 63. *Figures 57-60.* Cima cf. minima. *57: shell (0.82 mm); 58: protoconch view. 59: shell (0.79 mm); 60: protoconch. Figures 61-65:* Cima cylindrica. *61 and 63: shells (0.65 mm y 0.75 mm, respectively); 62 and 64: details of the microsculpture of the protoconch; 65: protoconch from figure 63.*

Género *Chauvetia*

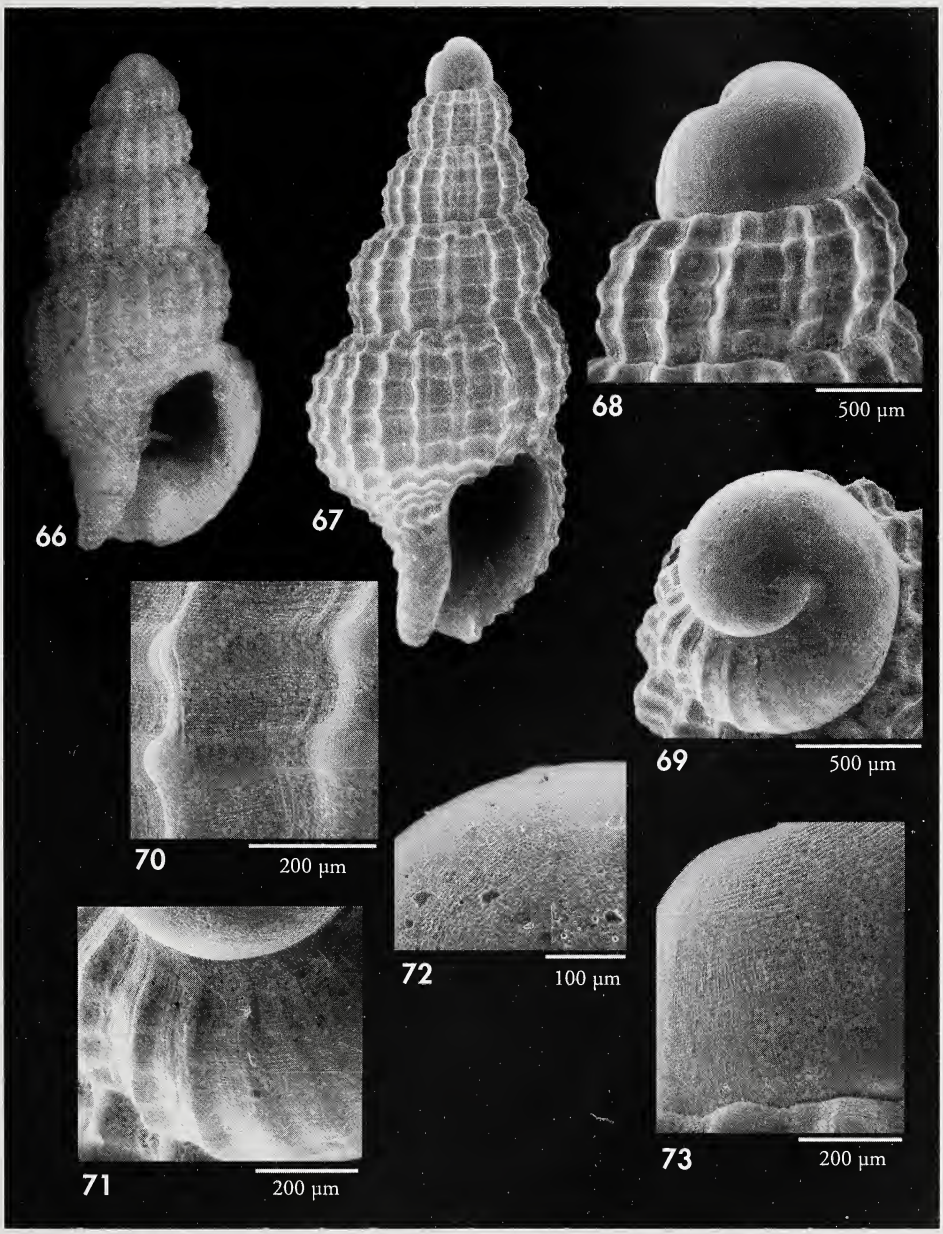
La correcta identificación de las especies pertenecientes al género *Chauvetia* muestra ciertas dificultades taxonómicas, en especial en el grupo que podríamos denominar *brunnea-mamillata-turritellata*. En las islas Columbretes se ha detectado la presencia de cinco especies de este género: *C. procerula* (Monterosato, 1889), *C. recondita* (Brugnone, 1873), *C. lineolata* (Tiberi, 1888), *C. mamillata* (Risso, 1826) y *C.* cf. *turritellata* (Deshayes, 1835). De ellas, *C. procerula* y *C. recondita* son bastante típicas y su correcta identificación no resulta problemática. Por otro lado, *C. lineolata* es una especie rara y en el presente estudio sólo hemos hallado protoconchas, fragmentos o alguna concha juvenil. A pesar de ello, hemos considerado válida su presencia al compararlas con una concha adulta procedente de la isla de Capraia, Italia (de la colección de Anselmo Peñas) (fig. 66) y con un subadulto perteneciente a la colección de Hidalgo (fig. 67) y en cuya etiqueta indica simplemente "España" como procedencia. Por ello, esta especie, aunque no se cita aquí por primera vez para España, sí que es la primera vez que se señala con una procedencia concreta en nuestro litoral.

Los ejemplares de *C. mamillata* de Columbretes presentan el típico patrón de color mamillado, al que la especie debe su nombre específico. Junto a ella aparece otra *Chauvetia* de color castaño rojizo uniforme a la que hemos denominado *C.* cf. *turritellata*. Aunque en la península Ibérica son frecuentes en *C. mamillata* otros patrones de color distintos al mamillado (lineado, castaño uniforme), no hemos detectado la presencia ni de conchas lineadas ni de conchas que puedan ser consideradas claramente intermedias. Además, tanto el tamaño como el aspecto de las protoconchas parecen distintos; la protoconcha de *C. mamillata* (figs. 76-77) es más voluminosa y presenta un menor número de costillas de transición que la de *C. cf. turritellata* (figs. 74 y 75). Por ello, hemos preferido considerarlas provisionalmente como especies distintas.

No obstante, queremos recalcar que esta asignación específica debe entenderse como provisional y no puede descartarse ni que se trate de dos formas de una única especie, ni que sean (una o ambas) especies distintas y endémicas. Por una parte, el taxon *C. turritellata* es confuso y está pendiente de una profunda revisión, en la que para llegar a conclusiones válidas se debería revisar material de todo el Mediterráneo, algo que, lógicamente, queda fuera de las pretensiones de este trabajo. Por otra parte, la batimetría a la que viven estas especies en Columbretes, la insularidad y su protoconcha pauciespiral, favorecerían la especiación en unas islas volcánicas que debieron colonizarse (en una o más invasiones) desde la Península (o Baleares).

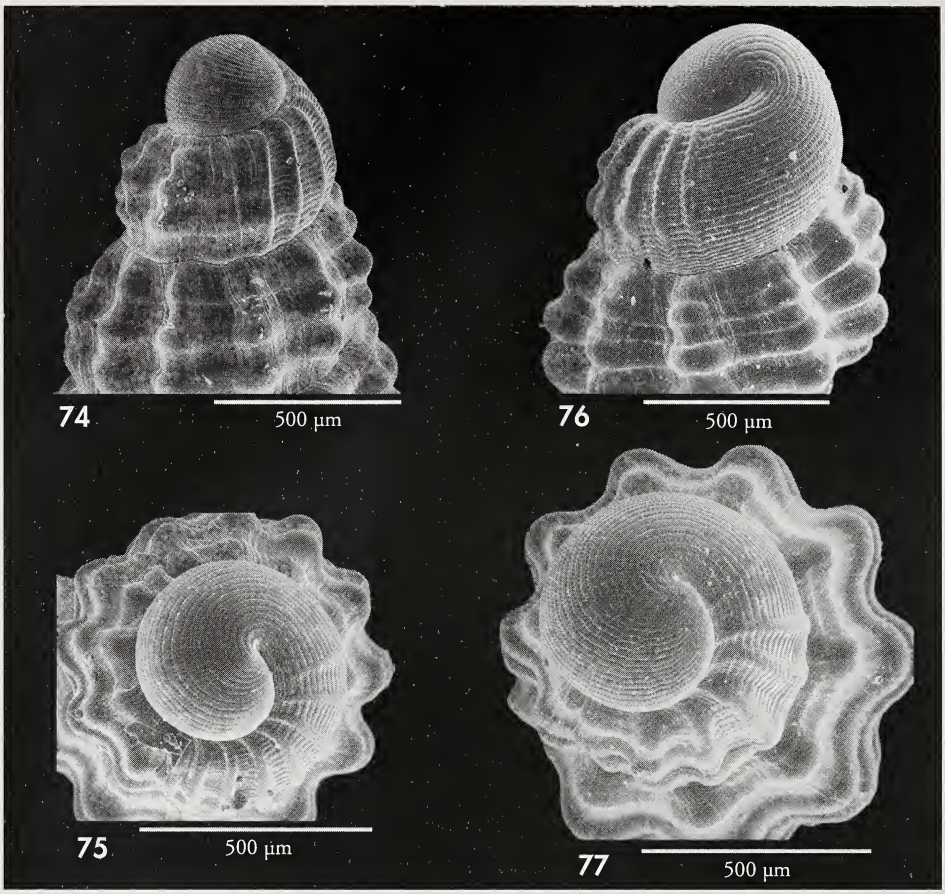
Familia Omalogyridae

Las conchas de las especies de la familia Omalogyridae son las de menor tamaño dentro de los moluscos. Presentan pocos rasgos morfológicos visibles con la lupa binocular y el uso del microscopio electrónico de barrido resulta imprescindible para su diferenciación, por lo que su estudio taxonómico es difícil. Creemos que se trata de una familia que puede reunir bastantes más especies de las que se aceptan por lo general y el material estudiado de Columbretes parece apuntar en este sentido. No obstante, algunas especies podrían ser bastante variables; por ejemplo, *Ammonicera fischeriana* parece serlo, tanto localmente como a lo largo de su área de distribución (observación personal).



Figuras 66-73. *Chauvetia lineolata*. 66: concha adulta (11,5 mm; Italia, col. Anselmo Peñas); 67: concha subadulta (8 mm, España, col. Hidalgo); 68: protoconcha de la figura 67; 69: vista apical de una protoconcha, de Columbretes; 70: detalle de la microescultura de la concha 67; 71: detalle de la transición protoconcha- teleoconcha; 72, 73: detalle de la microescultura de la protoconcha de la concha 67.

Figures 66-73. Chauvetia lineolata. *66: adult shell (11.5 mm; Italy, col. Anselmo Peñas); 67: subadult shell (8 mm, Spain, col. Hidalgo); 68: protoconch from figure 67; 69: apical view of a protoconch from Columbretes Islands; 70: detail of the microsculpture of the protoconch 67; 71: detail of the protoconch-teleoconch transition; 72, 73: detail of the microsculpture of the protoconch from the shell of figure 67.*



Figuras 74-75. *Chauvetia* cf. *turritellata*. 74: vista lateral de la protoconcha; 75: vista apical de la protoconcha. Figuras 76-77: *Chauvetia mamillata*.76: vista lateral de la protoconcha; 77: vista apical de la protoconcha.
Figures 74-75. Chauvetia cf. turritellata. *74: lateral view of the protoconch; 75: view of the protoconch. Figuras 76-77:* Chauvetia mamillata. *76: lateral view of the protoconch; 77: apical view of the protoconch.*

Género *Ammonicera*

La correcta identificación de las especies pertenecientes al género *Ammonicera* resulta complicada, dadas las dimensiones de las conchas, en general menores de 1 mm de diámetro. Por lo general, para separar las especies de este género se ha usado como criterio taxonómico la presencia de cordones y costillas y el color de la concha. Pero con conchas tan reducidas y de aspecto tan parecido, para el estudio de su escultura resulta imprescindible el uso del microscopio electrónico de barrido, más aún teniendo en cuenta que el aspecto de su diminuta protoconcha también tiene valor taxonómico.

En la base de datos CLEMAM se considera que el género *Ammonicera* incluye cuatro especies en el área geográfica que abarca (Atlántico nororiental y Mediterráneo). De ellas, dos estarían presentes en el Mediterráneo, *A. fischeriana* (Monterosato, 1869) y *A. rota* (Forbes y Hanley, 1850), mientras que las otras dos, *A. lignea* (Palazzi, 1988) y *A. rotundata* (Palazzi, 1988), serían macaro-

nésicas. AARTSEN *ET AL.* (1984) indican la presencia de *A. rota* y *A. fischeriana* en el área del estrecho de Gibraltar, aunque, a la hora de ilustrar ambas especies, eligen ejemplares procedentes de Italia. Por otro lado, FRETTER Y GRAHAM (1978) consideran que *A. fischeriana* y *A. rota* son la misma especie, mientras que otros autores, como GAGLINI Y CURINI-GALLETTI (1978), las consideran distintas, aunque concluyen que se trata de una cuestión todavía no resuelta. AARTSEN *ET AL.* (1984) se decantan, tras estudiar la colección de Bucquoy, Dautzenberg y Dollfus, por la segunda opción y consideran como *A. rota* a la especie cuya concha está uniformemente coloreada y que presenta las costillas algo desarrolladas, mientras que atribuyen a *A. fischeriana* las conchas habitualmente de mayor tamaño, con costillas débiles visibles en la primera vuelta y con líneas de color marrón. Por otro lado, como ya se ha indicado, PALAZZI (1988) describe dos nuevas especies de *Ammonicera* procedentes de Madeira: *A. rotundata* y *A. lignea*, y ROLÁN (1991) amplía hasta Cabo Verde la presencia de *A. rotundata*. Indica además este último autor que en el Mediterráneo únicamente estarían presentes *A. fischeriana*, en fondos meso- e infralitorales, y *A. rota*, más frecuente en fondos circalitorales. PALAZZI (1988) proporciona una clave dicotómica para distinguir estas cuatro especies. *A. rotundata* no presentaría carena (como puede observarse en visión lateral con el SEM), mientras que las otras tres sí. Además, esta especie tendría un color blanquecino y presentaría una marcada rugosidad radial. Por su parte, *A. rota* presentaría unas prominentes costillas radiales y una carena mediana poco evidente, frente a las otras dos que, serían claramente tricarinadas. Por último, *A. lignea* tendría un color uniforme, mientras que *A. fischeriana* presentaría la carena de color marrón dorado sobre fondo claro. PALAZZI (1988) aporta, asimismo, fotografías al SEM de todas las especies en visión apical, abapical y lateral. Sin embargo, dichas fotos plantean dudas al contrastarlas con su clave, en especial en lo referente a la relevancia de las carenas. Por ejemplo, la figura ilustrada por este autor como *A. fischeriana* (PALAZZI, 1988, fig. 11), procedente de Catania, se parece más a *A. lignea* (PALAZZI, 1988, fig. 8) que a la otra concha ilustrada de *A. fischeriana* (PALAZZI, 1988, fig. 12). Dicha concha de *A. fischeriana*, procedente de la isla Pantellería, es muy parecida a la ilustrada como *A. fischeriana* por AARTSEN *ET AL.* (1984), lo que no es de extrañar, dado que estos autores fotografiaron material procedente de las costas italianas.

En Columbretes hemos encontrado cuatro especies de *Ammonicera*. Dos de ellas las hemos determinado basándonos en aquellos trabajos que presentan fotografías al SEM, como los de AARTSEN *ET AL.* (1984), PALAZZI (1988) o ROLÁN (1991). Las otras dos especies no se ajustan a ninguna de las conocidas en el Mediterráneo, por lo que podría tratarse de especies no descritas. Sin embargo, hemos preferido no describirlas aquí, dado que este grupo requiere una revisión profunda de su taxonomía en la que se examinen los tipos y se estudie comparativamente mucho más material, con una cobertura geográfica amplia y, a ser posible, con datos del animal y genéticos. Todo ello queda pendiente y fuera de las pretensiones del presente trabajo.

Ammonicera fischeriana (Monterosato, 1869) (Figs. 78 y 79)

Seguimos aquí los criterios de AARTSEN *ET AL.* (1984), PALAZZI (1988) y OLIVER BALDOVÍ (2007) en la caracterización de esta especie. Presenta una concha planiespiral que con cerca de 3 vueltas alcanza 0,8 mm. Vista apicalmente al SEM (fig. 78) es prácticamente lisa con débiles estrías espirales. Además, en algunas conchas se puede apreciar un incipiente cordón espiral, más visible en la primera vuelta, que aparece primero junto a la sutura, para ir ocupando progresivamente una posición más central. Puede haber también débiles costillas

radiales que cruzan el cordón espiral formando débiles protuberancias.

La protoconcha con 1 a 1,25 vueltas puede alcanzar 185 μm. Vista apicalmente (fig. 79) se observan dos surcos. Uno central, que es perfectamente visible, y otro que coincide con la sutura y a veces es difícil de observar.

Ammonicera rota (Forbes y Hanley, 1850) (Figs. 80 y 81)

Se ha considerado como *A. rota* a la especie ilustrada como tal por Aartsen *et al.* (1984), Palazzi (1988) y Oliver Baldoví (2007), aunque tenemos serias dudas de que se trate de la misma especie descrita originalmente por Forbes y Hanley (1850), como se comenta más adelante.

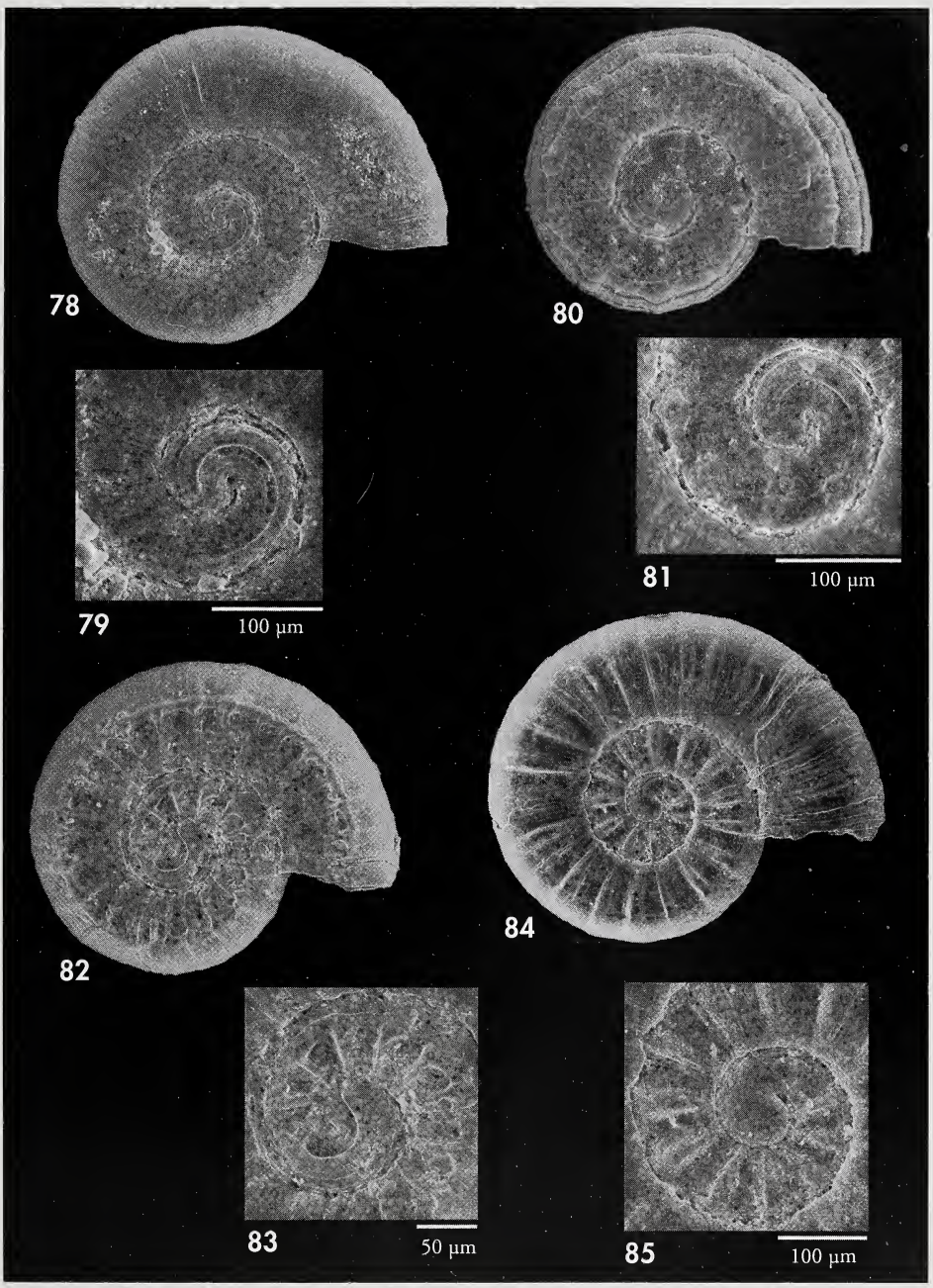
La concha (fig. 80) es planiespiral, anficóncava, y alcanza 0,5 mm de diámetro con 2,5 vueltas. Presenta en la periferia de la espira cinco cordones, que están juntos en la periferia de la concha y separados entre sí y del resto de la concha por débiles surcos. En visión apical se observan dos cordones enteros y la mitad del central. También se pueden observar delicadas costillas que al cruzar los cordones forman tubérculos, distanciados regularmente unos de otros y que resaltan en el perfil de la espira. En ocasiones son responsables de que la sutura sea algo ondulada. La transición de la protoconcha con la teleoconcha no es fácil de determinar; en ocasiones se observa una cicatriz en torno a una vuelta, pero ésta no es clara. Por ello, hemos considerado como final de la protoconcha la pérdida del aspecto granuloso de la misma, así como el inicio de los tubérculos en los cordones. Así pues, la protoconcha tendría una anchura de 135 μm con aproximadamente una vuelta. La protoconcha (fig. 81) presenta dos surcos proporcionalmente más estrechos que los de *A. fischeriana*. Uno de los surcos es prácticamente central, mientras que el otro está más próximo a la sutura y ocasionalmente queda oculto. Los dos surcos delimitan el cordón superior de la espira.

Ammonicera sp. 1 (Figs. 82 y 83)

La concha de esta *Ammonicera*, en visión apical (fig. 82), presenta un cordón situado aproximadamente en mitad de la espira. Esta situación se repite también en vista abapical. Estos cordones constituyen los rebordes de una banda ancha, de contorno redondeado situada en la periferia de la concha. Desde los cordones a las suturas (superior e inferior) el perfil de la espira es plano. También desde los cordones, y en sentido radial, salen costillas que llegan hasta la sutura, dándole a ésta un aspecto algo ondulado. Las costillas son más estrechas que los espacios intercostales, que recuerdan a las casillas de una ruleta. Abapicalmente el aspecto de la concha es parecido.

La protoconcha (fig. 83) alcanza 110 μm de anchura con media vuelta. Como la transición con la teleoconcha es poco clara, se ha considerado que comienza justo antes de la primera costilla. Vista apicalmente presenta dos surcos, uno superior que delimita superiormente el cordón y que es interrumpido rápidamente por las costillas. El inferior discurre junto a la sutura para desaparecer tras recorrer 1,5 vueltas aproximadamente. Los surcos están resaltados por un estrecho reborde.

Esta especie ya había sido mencionada por Oliver Baldoví (2007) en el Golfo de Valencia como *Ammonicera* sp. También la hemos encontrado en material procedente de las islas Chafarinas, por lo que su área de distribución se presume que puede ser bastante amplia. Se parece mucho a las conchas juveniles de *A. fischeriana*, pero se diferencia de ésta por su relieve mucho más acusado, aunque para distinguirlas claramente es



Figuras 78, 79. *Ammonicera fischeriana.* 78: vista apical de la concha (0,82 mm de diámetro); 79: vista apical de su protoconcha; Figuras 80, 81. *Ammonicera rota.* 80: vista apical de concha (0,47 mm); 81: protoconcha. Figuras 82, 83. *Ammonicera* sp.1. 82: vista apical de concha (0,52 mm); 83: protoconcha. Figuras 84, 85. *Ammonicera* sp. 2. 84: vista apical de concha (0,84 mm); 85: protoconcha. *Figures 78, 79.* Ammonicera fischeriana. *78: apical view of the shell (0.82 mm diameter); 79: apical view of the protoconch; Figures 80, 81.* Ammonicera rota. *80: apical view of the shell (0.47 mm); 81: protoconch. Figures 82, 83.* Ammonicera *sp.1. 82: apical view of the shell (0.52 mm); 83: protoconch. Figures 84, 85.* Ammonicera *sp. 2. 84: apical view of the shell (0.84 mm); 85: protoconch.*

preciso comparar sus protoconchas. La de *A. fischeriana* tiene una vuelta, mientras que la de *Ammonicera* sp. 1 sólo tiene media. También se diferencia por detalles de su escultura. Por otra parte, la diferencia con *A. rota* radica en que el cordón-banda periférico no está subdividido en cinco cordones. Los espacios intercostales en *A. rota* no tienen tampoco el aspecto de casilla de ruleta que se puede observar en *A.* sp.1. También las protoconchas son algo distintas, ya que los surcos en *A.* sp.1 tienen un reborde que no se aprecia en *A. rota*. Con todo, preferimos no describirla a la espera de una revisión más amplia del grupo y del examen del material tipo de *A. rota*.

Ammonicera sp. 2 (Figs. 84-85)

La concha de esta *Ammonicera* (fig. 84) es planiespiral anficóncava y alcanza 840 µm con cerca de 3 vueltas. Presenta un único cordón espiral ancho y plano que discurre por la periferia de la espira y que se separa del resto de la concha por un débil surco. Presenta costillas algo más estrechas que sus interespacios, los cuales se elevan sobre todo entre el surco y la sutura sin que se aprecien diferencias significativas apical o abapicalmente. Los cordones se aplanan sobre el cordón periférico y no resaltan en el contorno de la concha. Las conchas son de color marrón rojizo uniforme, salvo alrededor del peristoma que es de color blancuzco.

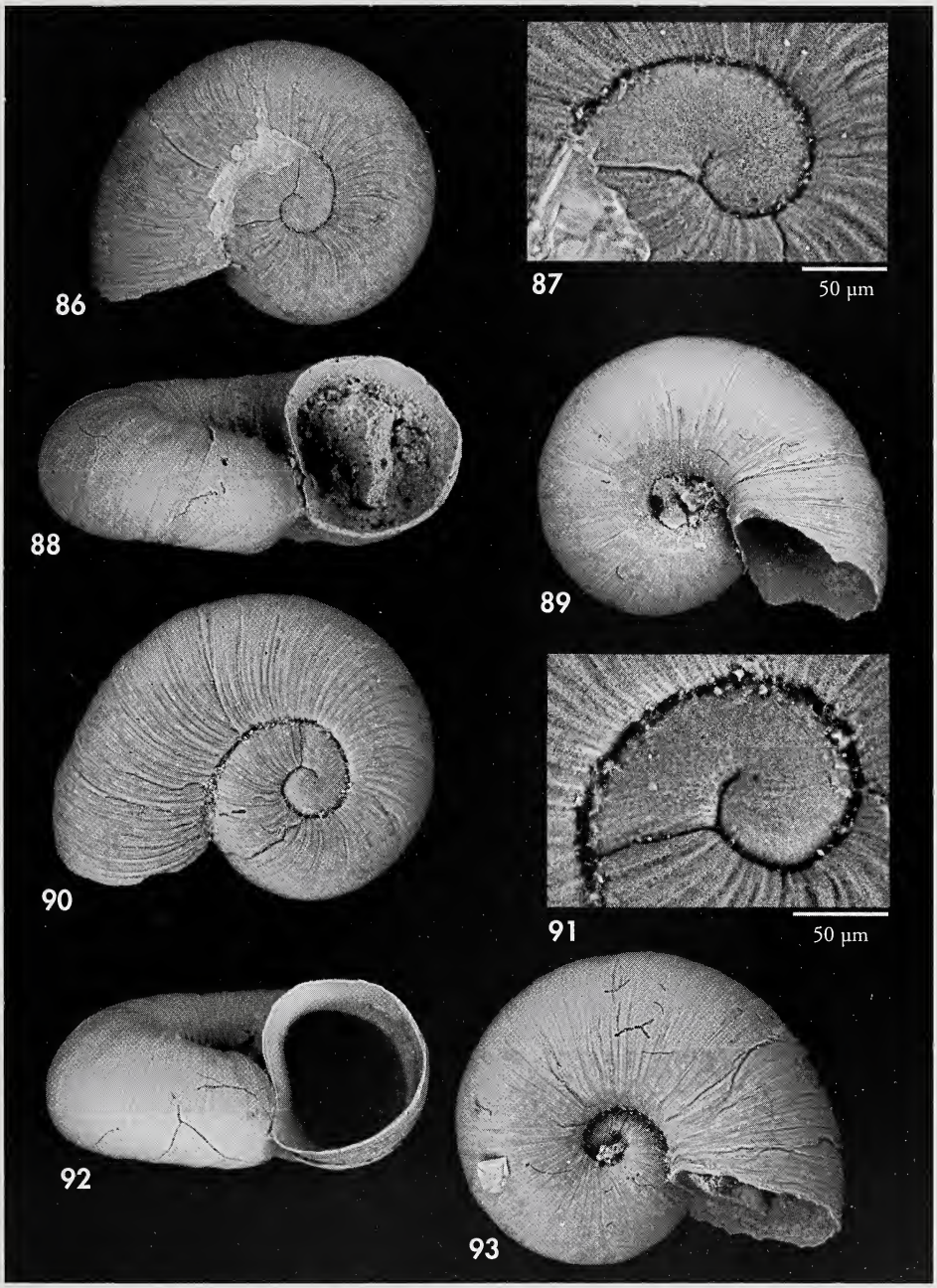
La protoconcha (fig. 85) con tres cuartos de vuelta alcanza una anchura de 125 µm. En ella se aprecia un surco que aparece en la zona central, va acercándose progresivamente a la sutura y se continúa con el surco que separa el cordón central del resto de la espira. La transición con la teleoconcha no es clara y se ha considerado que ésta última comienza cuando desaparece el granulado y se inician las costillas.

El color marrón rojizo de la concha y la elevación de las costillas la distinguen claramente de otras *Ammonicera*. Si se observa esta especie con una lupa binocular y se compara con la que Aartsen *et al.* (1984) y Palazzi (1988) consideran *A. rota*, resulta evidente que *Ammonicera* sp. 2 presenta unas costillas más evidentes y un color marrón rojizo uniforme, mientras que *A. rota*, aunque tiene costillas, presenta un aspecto más bien tuberculado y un color blanco perlado con una línea rojiza. Además, *A.* sp. 2 es mayor (unos 0,8 mm) que *A. rota* (unos 0,5 mm).

Género *Retrotortina*

Al examinar las conchas de *Retotortina* de Columbretes hemos observado que presentaban dos patrones de color. Un grupo de conchas era de color castaño rojizo con tonalidades doradas, mientras que otras eran transparentes, con tonalidades amarillentas y con tenues líneas rojizas axiales. Ante la posibilidad de que nos encontráramos ante dos especies distintas y dado que solamente se conocen dos especies de *Retrotortina*, una de ellas africana (*R. damara* Rolán, Luque y Peñas, 2009), se realizaron fotografías y mediciones de varias protoconchas de ambos grupos de conchas.

Las conchas de *Retrotortina* de color castaño rojizo (figs. 86-89) las hemos asignado a la única especie europea conocida del género, *R. fuscata* Chaster, 1896, aunque hemos observado algunas diferencias, sobre todo en la protoconcha, con respecto a las características apuntadas por Gofas y Waren (1998). Según estos autores, la protoconcha de *R. fuscata* tiene una vuelta y alcanza entre 175 y 200 µm de diámetro. Nosotros hemos estudiado cuatro conchas elegidas al azar, y en ellas su protoconcha no llega a alcanzar una vuelta y sus dimensiones son claramente menores, entre 130 y 135 µm.



Figuras 86-89. *Retrotortina fuscata*. 86: vista abapical de una concha de 0,58 mm de diámetro; 87: detalle de la protoconcha; 88: vista lateralde una concha de 0,69 mm; 89: vista apical de una concha de 0,61 mm. Figuras 90-93. *Retrotortina* sp. 90: vista abapical concha (0,62 mm de diámetro); 91: protoconcha; 92: vista lateral de una concha de 0,55 mm; 93: vista apical de la misma.
Figures 86-89. Retrotortina fuscata. *86: abapical view of a shell of 0.58 mm diameter; 87: detail of the protoconch; 88: lateral view of a shell of 0.69 mm; 89: apical view of a shell of 0.61 mm. Figures 90-93.* Retrotortina *sp. 90: abapical view of a shell (0.62 mm diameter); 91: protoconch; 92: lateral view of a shell of 0.55 mm; 93: apical view of the same shell.*

El otro grupo de conchas estudiadas de *Retrotortina* son transparentes o amarillentas. Al compararlas con las conchas de Columbretes asignadas a *R. fuscata*, hemos observado algunas diferencias que creemos significativas, por lo que podría tratarse de una especie distinta que hemos optado por designarla como *Retotortina* sp.

Retrotortina sp. (Figs. 90-93)

Su concha (figs. 90, 92 y 93) es heterostrofa y alcanza 0,62 mm de diámetro con 1,8 vueltas. Es transparente y en algunos casos presenta líneas axiales de tonalidades rojizas. Escultura limitada a las líneas de crecimiento, que vistas al SEM le dan un aspecto algo arrugado, especialmente al inicio de la teleoconcha. Su protoconcha (fig. 91) es pauciespiral, lisa, con 0,7 vueltas y alcanza 0,16 mm de diámetro.

Se distingue de *R. fuscata* por su color, porque su labio interno al apoyarse sobre la espira presenta una curvatura más pronunciada que en *R. fuscata* y por su ombligo más estrecho (fig. 93). Como la protoncha de las especies de *Retrotortina* es pauciespiral y lisa, no tiene rasgos diferenciadores claros que nos permitan distinguir sin dificultad las especies. A pesar de ello, tras fotografiar cuatro protoconchas de *R. fuscata* y cuatro de *Retrotortina* sp. elegidas de forma aleatoria hemos observado que el núcleo de esta última es más voluminoso y su protoconcha más ancha (150 y 165 μm, frente a 130 y 135 μm en *R. fuscata*).

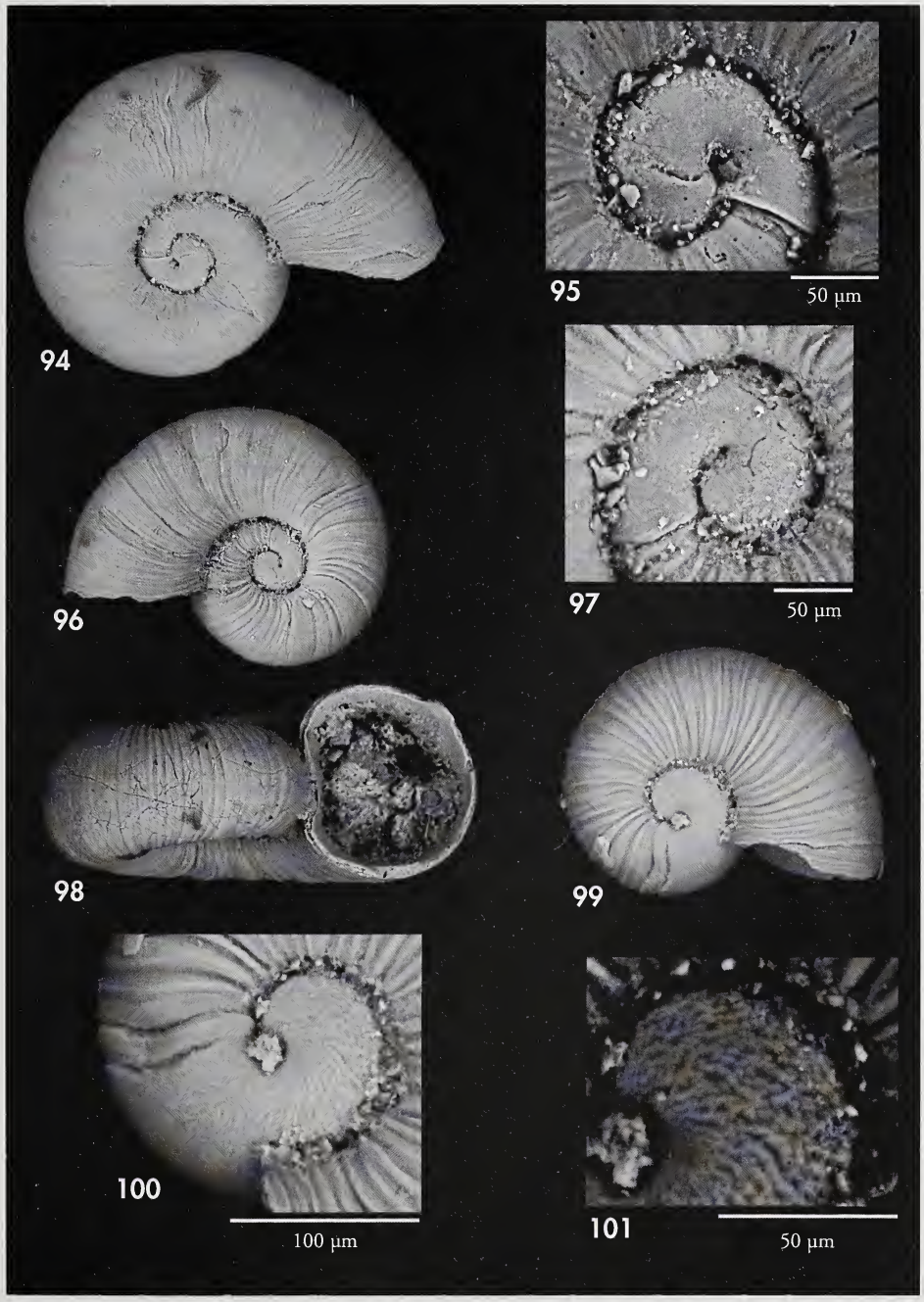
Género *Omalogyra*

Dos especies de *Omalogyra* se hallan presentes en Columbretes, *O. atomus* (Philippi, 1841) y *O. simplex* (O.G. Costa, 1861), si bien ésta última podría agrupar dos especies crípticas. El género *Omalogyra* incluye especies de concha planospiral y anficóncava, con pocos detalles en su escultura y con unas dimensiones que no llegan a alcanzar un milímetro de diámetro.

La base de datos CLEMAM considera cuatro especies válidas para el Atlántico nororiental y Mediterráneo, las dos mencionadas anteriormente, del Mediterráneo y encontradas en Columbretes, y otras dos descritas por Palazzi (1988) en Madeira, *O. undosa* y *O. circulus*. Posteriormente, Rolán (1991) amplía el área de distribución de *O. atomus* y *O. disculus* hasta Cabo Verde y describe dos nuevas especies de Cuba (Rolán, 1992). Dicho autor apunta la posibilidad de que el género agrupe un mayor número de especies, dado que alguna de ellas (como *O. atomus*) se ha citado tanto en las costas europeas como en las de Sudamérica. Teniendo en cuenta que las especies de *Omalogyra* presentan una protoconcha pauciespiral y, por tanto, posiblemente tengan un desarrollo sin una fase pelágica, lo que limitaría su capacidad de dispersión, es probable que existan muchas más especies de las actualmente descritas, no diferenciadas hasta ahora por su reducido tamaño y por los pocos detalles diferenciadores que presentan sus conchas.

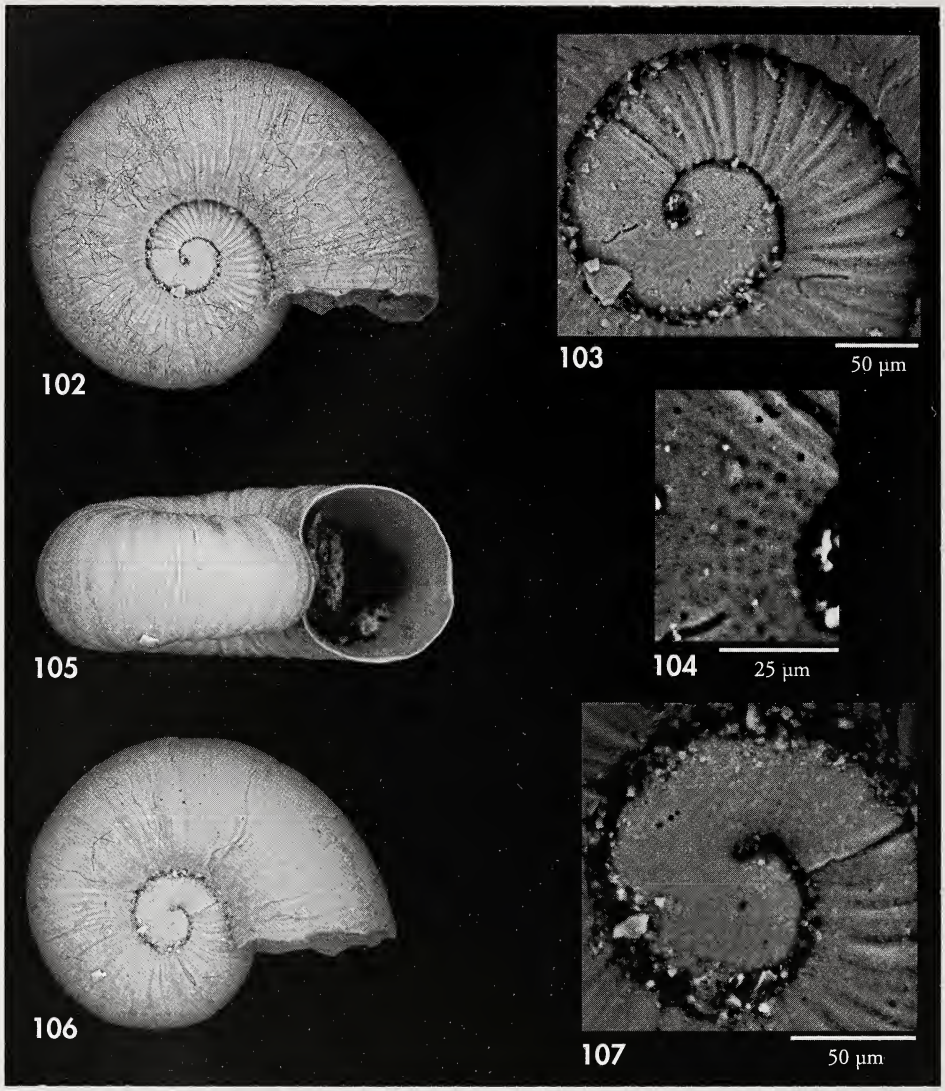
En el presente trabajo no hemos considerado conveniente describir como especies nuevas aquellas que no coincidieran totalmente con las descripciones que aparecen en la literatura, ya que para ello hubiera sido necesario una revisión general del género y el estudio de los tipos, algo que quedaba fuera de los objetivos del estudio.

Omalogyra simplex (figs. 94-101) se caracteriza por tener una concha transparente, algo amarillenta, en la que destacan líneas rojizas oblicuas que, vista la concha de frente, se disponen en forma de "V" con el vértice apuntando hacia la abertura. Según Palazzi (1988), la concha de esta especie presenta una fuerte rugosidad radial, una protocon-



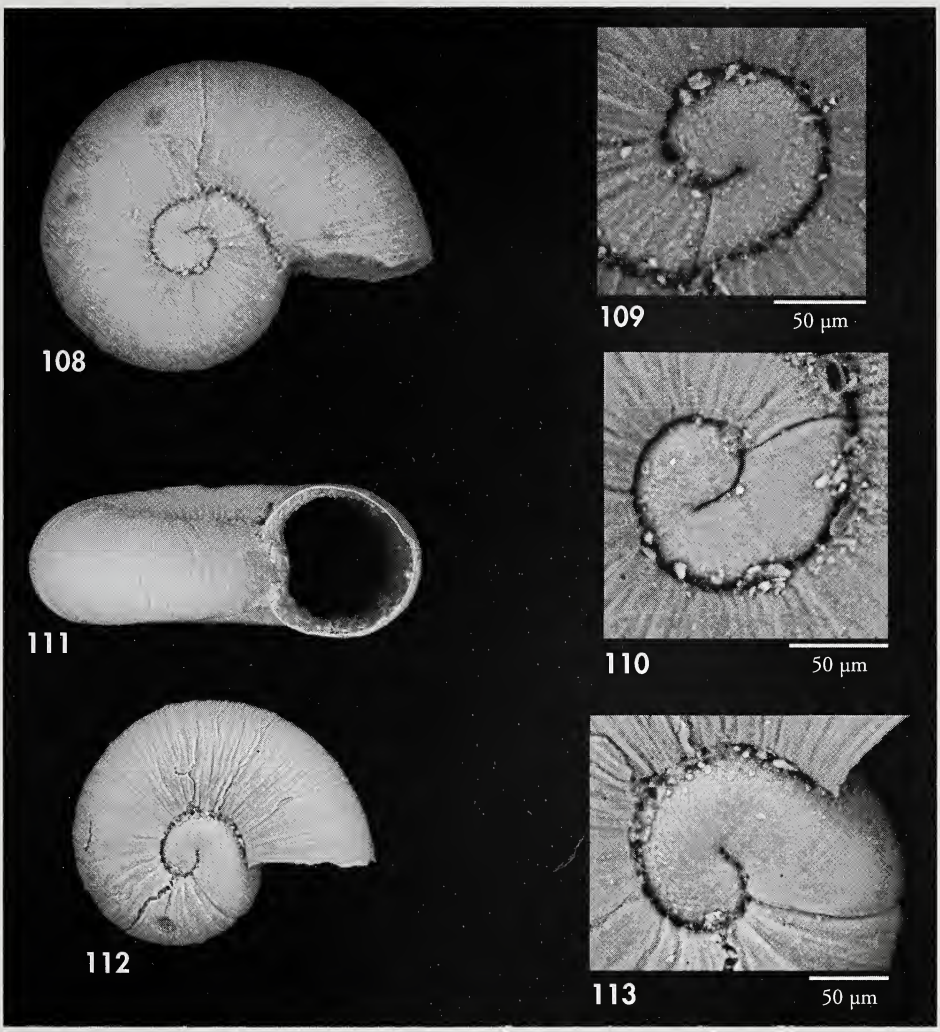
Figuras 94-101. *Omalogyra simplex*. 94: vista apical de una concha de 0,77 mm de diámetro; 95: protoconcha; 96: vista abapical de una concha de 0,67 mm; 97: protoconcha; 98: vista frontal de una concha de 0,73 mm; 99: vista apical de un juvenil (0,37 mm); 100: vista de su protoconcha; 101: vista de la microescultura de la protoconcha.

Figures 94-101. Omalogyra simplex. *94: apical view of a shell of 0.77 mm diameter; 95: protoconch; 96: abapical view of a shell of 0.67 mm; 97: protoconch; 98: frontal view of a shell of 0.73 mm; 99: apical view of a juvenile shell (0,37 mm); 100: protoconch; 101: protoconch microsculpture.*



Figuras 102-107. *Omalogyrus* cf. *simplex*. 102: vista apical de la concha (0,79 mm de diámetro); 103: detalle de su protoconcha; 104: detalle de la microescultura de la protoconcha; 105: vista frontal de una concha de 0,67 mm; 106: vista apical de un subadultos de 0,53 mm; 107: detalle de su protoconcha.
Figures 102-107. Omalogyrus cf. simplex. *102: apical view of the shell (0.79 mm diameter); 103: detail of the protoconch; 104: detail of the microsculpture of the protoconch; 105: frontal view of a shell of 0.67 mm; 106: apical view of an subadult shell (0.53 mm); 107: detail of the protoconch.*

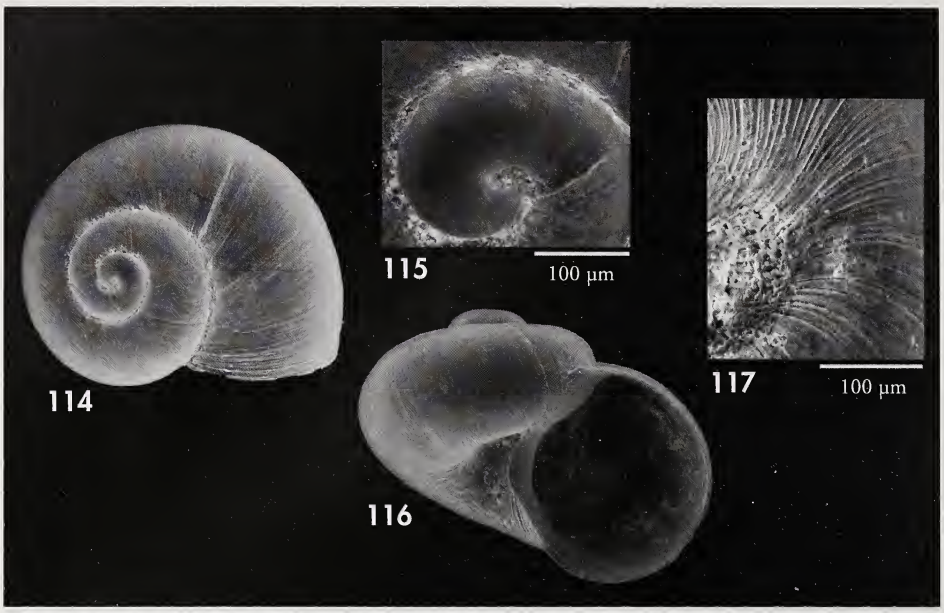
cha lisa y un labio circunflexo. Tales características se dan en las conchas encontradas en Columbretes, si bien, el aspecto de la protoconcha a grandes aumentos (fig. 101) no parece ser completamente liso. Por otro lado, el examen con la lupa binocular de conchas de esta especie mostraba que algunas conchas eran transparentes, de color blanco amarillento, y carecían de las líneas oblicuas anaranjadas características de *O. simplex*. Al examinar con el microscopio electrónico conchas de ambos patrones de color se observó la



Figuras 108-113. *Omalogyrus atomus.* 108: vista apical de una concha de 0,52 mm; 109: vista apical de la protoconcha; 110: vista abapical de una protoconcha; 111: vista frontal de una concha de 0,70 mm; 112: vista apical de un juvenil de 0,41 mm; 113: detalle de su protoconcha.
Figures 108-113. Omalogyrus atomus. *108: apical view of a shell of 0.52 mm; 109: apical view of the protoconch; 110: abapical view of the protoconch; 111: frontal view of a shell of 0.70 mm; 112: apical view of a juvenile shell of juvenile 0.41 mm; 113: detail of its protoconch.*

existencia de dos tipos de protoconcha, pero que no parecían estar relacionados con el patrón de color. Por tal motivo, hemos optado por denominar como *O.* cf. *simplex* (fig. 102-107) a aquellas conchas cuya protoconcha es más rugosa y presenta como unas fosetas alineadas longitudinalmente, visibles sobre todo en la zona subsutural al final de la protoconcha. En estas conchas, además, la transición de la protoconcha con la teleoconcha es más recta que en la que hemos considerado como la verdadera *O. simplex,* cuya concha parece aumentar más lentamente de volumen.

Por otra parte, PALAZZI (1988) describió *O. undosa* a partir de conchas procedentes de Madeira con una fuerte rugo-



Figuras 114-117. *Hyalogyra zibrowii*.114: concha en vista apical (1,25 mm de diámetro); 115: protoconcha; 116: concha en vista frontal (0,84 mm); 117: detalle de la escultura del ombligo.
Figures 114-117. Hyalogyra zibrowii.*114: apical view of the shell (1.25 mm de diámetro); 115: protoconch; 116: frontal view of the shell (0.84 mm); 117: detail of the umbilical sculpture.*

sidad que se va desvaneciendo en el último giro, labio rectilíneo y con una protoconcha rugosa. Aunque nuestros ejemplares de *O.* cf. *simplex* coinciden en gran medida con esta descripción, hemos preferido, en tanto no se haga un estudio más profundo y basado en un mayor número de ejemplares, no asignar los ejemplares de Columbretes a la especie de Madeira.

Ommalogyra atomus (figs. 108-113), por su parte, es de color amarillento con el inicio de la concha castaño rojiza y con cinco líneas paralelas de este mismo color. Dos de ellas se sitúan en la sutura, una en la periferia de la concha y otras dos entre esta línea y la sutura. El patrón de color de la concha recuerda al de las especies de *Ammonicera*, por lo que es fácil que sea confundida con individuos jóvenes de *A. fischeriana*, si bien las protoconchas de las especies de estos dos géneros son completamente distintas. Palazzi (1988) indica que *O. atomus* carece de rugosidad radial y tiene la protoconcha lisa. Las conchas de Columbretes son, efectivamente, más lisas que *O. simplex*. Además, la abertura es más redondeada. Las protoconchas de conchas típicas de *O. simplex* y de *O. atomus* presentan un aspecto liso con una débil decoración granulada semejante, pero se diferencian en que la transición con la teleoconcha de *O. simplex* es más sinuosa que la de *O. atomus*.

Hyalogyra zibrowii Waren in Waren, Carrozza y Rochini, 1997 (Figs. 114-117)

Se trata de una especie muy parecida a *Xenoskenea pellucida*, de la que se diferencia por tener un ombligo más estrecho, y que fue incluida tentativamente dentro de la familia Hyalogyrinidae, dado que se desconoce todavía el animal (Waren, Carrozza y Rochini, 1997). Esta especie sólo se conocía en el mar de Alborán y en las costas mediterráneas francesas.

DISCUSIÓN

En las muestras estudiadas en el presente trabajo se han encontrado en total 257 especies, de las cuales 119 no se habían citado con anterioridad en las Columbretes y, además, una de ellas se describe como nueva. Como consecuencia de ello, el número de especies de gasterópodos marinos citados en estas islas asciende a 323. No obstante, con anterioridad se habían incluido en la lista de especies de moluscos del archipiélago algunas especies recogidas en fondos de la plataforma continental cercanos al mismo, como *Lepetella espinosae* Dantart y Luque, 1994, *Danila otaviana* (Cantraine, 1835) o *Eulimella ventricosa* (Forbes, 1844), pero que no deben considerarse como especies propias de este enclave insular, sino de la plataforma circundante, como otras muchas que tampoco se han incluido.

Quizá cabe resaltar algunas ausencias significativas en Columbretes de especies comunes en las costas peninsulares próximas, por no encontrarse en estas islas determinados tipos de hábitats, como ensenadas o enclaves protegidos del hidrodinamismo intenso. Faltan por ejemplo, varias de las especies de tróquidos propios de estos ambientes de aguas calmadas, como *Phorcus articulatus* (Lamark, 1822), *Phorcus richardi* (Payraudeau, 1826), *Gibbula divaricata* (Linnaeus, 1758), *G. rarilineata* (Michaud, 1829) o *G. varia* (Linnaeus, 1758). También faltan algunas especies muy comunes en las praderas de *Posidonia oceanica*, ausentes en los fondos del archipiélago, como *Gibbula umbilicaris* (Linnaeus, 1758), *Rissoa auriscalpium* (Linnaeus, 1758) o *Tricolia speciosa* (von Mühlfeld, 1824). Por otro lado, no hemos podido corroborar la presencia de la especie *Tricolia pullus* (Linnaeus, 1758), citada por TEMPLADO *ET AL.* (2002) y también característica de las praderas de *P. oceanica*. Probablemente pudo ser confundida con *T. tenuis* (Michaud, 1828), muy abundante y algo variable en Columbretes y característica de las praderas de *Cymodocea nodosa*, fanerógama marina que sí forma notables praderas en Columbretes. Por supuesto, faltan también especies propias de medios lagunares o de fondos fangosos someros, como puede ser *Nassarius corniculum* (Olivi, 1792).

Por otro lado, con motivo del presente estudio se ha realizado un análisis crítico de todo lo publicado hasta la fecha sobre las especies de moluscos de este enclave insular. Como resultado de ello, algunas de las especies citadas con anterioridad nos ofrecen dudas, como la ya citada *Tricolia pullus*, por lo que su presencia en este enclave insular creemos que debe ser reconsiderada. Se trata de las siguientes:

- Especies del género *Jujubinus*. TEMPLADO *ET AL.* (2002) indican la presencia de cinco especies de este género en las Columbretes: *J. montagui* (Wood, 1828), *J. gravinae* (Dautzenberg, 1881), *J. exasperatus* (Pennant, 1777), *J. striatus* (Linnaeus, 1758) y *J. ruscurianus* (Weinkauff, 1868). Las dos primeras especies son fácilmente identificables y se ha ratificado su presencia. *Jujubinus montagui* posiblemente se encuentre en los fondos detríticos circalitorales y *J. gravinae* en las praderas de *Cymodocea nodosa* y algas fotófilas de fondos infralitorales. Por otro lado, en principio *J. striatus* y *J. exasperatus* han sido las especies del género más abundantes en el material estudiado. A pesar de ello, no ha sido posible determinar con certeza que se trate de dos especies distintas o bien de una única especie altamente variable. Hemos optado por considerar válida la presencia de *Jujubinus exasperatus*, cuyas conchas en el archipiélago se corresponden con la forma que habitualmente se ha denominado *corallina*. Sin embargo, no se han encontrado conchas con la forma típica o con la forma denominada *monterosatoi*, muy frecuentes en las costas peninsulares. En cuanto a *J. striatus*, tampoco se han encontrado conchas que pudiéramos asignar inequívocamente a este taxon, por lo que se ha optado por denominarlas *Jujubinus* cf. *striatus*. Se diferencian de *J. exasperatus* por no tener un claro cordón basal, carecer de cordones granulados o por ser sus juveniles proporcionalmente más anchos y lisos. A pesar de esto, en muchos casos ha resultado difícil asignar a uno u otro taxon las conchas estudiadas. Dada la escasa capacidad de dispersión

que parecen presentar la especies de este género y su gran variabilidad, nos inclinamos por pensar que estas dos especies presentan en Columbretes formas locales en proceso de especiación incipiente.

En cuanto a *J. ruscurianus*, creemos que esta especie no se halla presente en Columbretes. Seguramente fue confundida con juveniles de color rojizo de las anteriores. Se han comparado centenares de conchas precedentes del archipiélago, cuyo aspecto pudiera ser parecido al de *J. ruscurianus*, con verdaderos ejemplares de esta especie procedentes del sur y sureste peninsular y en ningún caso coincidían. Por lo tanto, esta especie debe ser excluida de la malacofauna de Columbretes.

- *Alvania discors* (Allan, 1818). Templado *et al.* (2002) citan esta especie en las islas, pero tras examinar minuciosamente todo el material de las muestras, así como el depositado en el MNCN procedente del archipiélago, no se ha podido confirmar su presencia. Por ello, consideramos que debe ser también excluida. Probablemente haya sido confundida con *A. lineata* Risso, 1826, muy abundante en este entorno insular y que presenta en Columbretes una gran variabilidad cromática. Resulta curiosa la ausencia de *A. discors*, pues esta especie tiene protoconcha multiespiral, mientras que *A. lineata* la tiene pauciespiral y ello debería ser indicativo de una mayor capacidad de dispersión larvaria de la primera frente a la segunda. Dado que ambas especies están presentes y son comunes tanto en las costas peninsulares más próximas (Oliver Baldoví, 2007) como en las islas Baleares (observación personal), sería más lógico pensar que fuera *A. discors* y no *A. lineata* la especie presente en Columbretes. Ello indica que no siempre se cumplen las previsiones sobre la capacidad de dispersión de las especies a partir de sus protoconchas y que deben existir otros factores determinantes del alcance de la dispersión.

- *Alvania subcrenulata* (Bucquoy, Dautzenberg y Dollfus, 1884) fue citada por Templado *et al.* (2002), pero no se ha podido ratificar ahora su presencia en Columbretes, aunque sí se halla en Baleares (observación personal). No descartamos su presencia a mayor profundidad, pero las conchas estudiadas corresponden todas a la especie recientemente descrita *A. balearica* (Oliver y Templado, 2009) con la que probablemente fue inicialmente confundida.

- *Gibberula oryza* (Lamarck, 1822). La correcta determinación de las especies pertenecientes al género *Gibberula* resulta muy difícil si sólo se dispone de la concha y no se comprueba la coloración del animal (Gofas, 1990). Templado *et al.* (2002) indicaron la presencia en Columbretes de *Gibberula miliaria* (Linnaeus, 1758), *Gibberula philippi* (Monterosato, 1878) y *Gibberula oryza*. El examen del material estudiado en el presente trabajo nos confirma la presencia de *G. philippi* y, además, se ha constatado la presencia de *Gibberula caelata* (Monterosato, 1877), especie también presente en la costa peninsular próxima a Columbretes, como en el Garraf (Giribet y Peñas, 1997) o en el Golfo de Valencia (Oliver Baldoví, 2007), y que no había sido citada para Columbretes. En cuanto a *Gibberula miliaria* se trata de una especie muy frecuente en las costas peninsulares y en las islas Baleares. Sus conchas son de color blanco amarillento y suelen presentar cuatro bandas más rojizas, aunque en algunas conchas pueden estar ausentes, limitándose el color rojizo a la sutura. Las conchas estudiadas de Columbretes no presentaban la coloración típica de bandas. Algunas eran blancas, pero otras presentaban una franja naranja ancha similar a la que se observa en *Gibberula oryza*. Sin haber visto la coloración del animal, no se puede asegurar que se trate de *Gibberula miliaria*, pero por razones de abundancia y proximidad podría serlo. En cambio, no creemos que pueda tratarse de *Gibberula oryza*, una especie del oeste de África que en el Mediterráneo no penetra mucho más allá del Estrecho de Gibraltar. Por ello, hemos creído conveniente referirnos a la especie presente en Columbretes como *Gibberula* cf. *miliaria* y no considerar válida la presencia en de *Gibberula oryza*.

En lo que se refiere a otros aspectos reseñables, cabe destacar que las especies de algunos grupos encontradas en Columbretes, como las del género *Dikoleps*, no se ajustan del todo a los caracteres de las especies ya conocidas (como ya se ha comentado) y podrían considerarse como formas insulares en proceso de especiación que requerirían de un estudio comparativo más detallado. Lo mismo sucede con algunas especies de los géneros *Cerithiopsis*, *Chauvetia* o de la familia Omalogyridae, muy diversificada en estas islas, habiéndose encontrado unas 9 en este enclave insular, tres de la cuales podrían ser especies no descritas.

Por último, cabe mencionar que dos de los grupos con mayor abundancia de ejemplares y de especies en este tipo de sedimentos bioclásticos en otras zonas, como los Pyramidellidae y Eulimidae (estoparásitos de poliquetos y moluscos, los primeros, o de equinodermos, los segundos), han sido muy escasos en las muestras estudiadas, posiblemente por ser escasos sus hospedadores en el entorno de las islas. Aunque se han encontrado 31 especies de Piramidélidos en las muestras estudiadas, el número de ejemplares presentes ha sido muy bajo. Las únicas especies con una presencia significativa han sido *Chrysallida excavata* (Philippi, 1836), *C. interstincta* (J. Adams, 1797), *C. intermixta* (Monterosato, 1884), *Odostomella doliolum* (Philippi,1844), *Odostomia carrozzai* Van Aartsen,1987, *Odostomia scalaris* McGillivray, 1843 y *O. striolata* Forbes y Hanley, 1850. Por el contrario, especies como *O. conoidea* (Brocchi, 1814), abundante en las costas peninsulares, no han sido encontradas y la presencia de otras, como *O. eulimoides* Hanley, 1844 o *T. pusilla* (Philippi, 1844) es prácticamente testimonial.

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A new species of *Phorcus* (Vetigastropoda, Trochidae) from the Cape Verde Islands

Una nueva especie de *Phorcus* (Vetigastropoda, Trochidae) del archipiélago de Cabo Verde

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ABSTRACT

A recent molecular study has shown that the well-known intertidal Cape Verde topshell, previously identified as *Osilinus punctulatus*, *O. tamsi* or *O. atratus*, is a distinct undescribed species (Donald, Preston, Williams, Reid, Winner, Alvarez, Buge, Hawkins, Templado & Spencer, 2012). Therefore we describe it here as new for science and compare it to the closest species.

RESUMEN

Un estudio reciente basado en técnicas moleculares ha demostrado que la especie intermareal de las islas de Cabo Verde previamente identificada como *Osilinus punctulatus*, *O. tamsi* u *O. atratus*, es en realidad una especie diferente no descrita (Donald, Preston, Williams, Reid, Winner, Alvarez, Buge, Hawkins, Templado & Spencer, 2012). Por lo tanto, la describimos aquí como nueva para la ciencia y la comparamos con las especies más próximas.

INTRODUCTION

The more important and common algal grazers of intertidal rocky sea-shores of the northeastern Atlantic Ocean and Mediterranean Sea are limpets (of the genera *Patella* and *Cymbula*), winkles (of the genera *Littorina*, *Melarhaphe* and *Echinolittorina*) and topshells (of the genera *Gibbula* and *Phorcus*). The genus *Phorcus* has been recently redefined (Donald et al., 2012) to include species previously under the genus names *Monodonta* or *Osilinus*. The classification of *Osilinus* has been historically confused, with species often included within the genus *Monodonta* (Gofas & Jabaud, 1997), in the Gibbulini tribe of the subfamily Trochinae (Hickman & Mclean, 1990). Nevertheless, *Osilinus* is morphologically (Hickman & Mclean, 1990) and genetically (Donald, Kennedy and Spencer, 2005) distinct from *Monodonta* and, based on molecular evidence, *Osilinus* has recently been moved into the subfamily Cantharidinae, separate from the Monodontinae and Trochinae (Williams, Donald, Spencer & Nakano, 2010). Species classification within *Osilinus* has also been unstable. Nordsieck (1982) recognised 16 species in the northeastern Atlantic and Mediterranean Sea, whereas Beck (1995) synonymized many of these species, reducing the total number to nine, and later Crothers (2001) recognised six species. On the other hand, Gofas & Jabaud (1997) restored the genus *Phorcus* Risso,

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1826, restricted to the Mediterranean, to include *O. mutabilis* and the type species commonly referred as *Gibbula richardi*, and they pointed out their close relationships to *Osilinus* Philippi, 1847. Recently, a complete molecular phylogeny of the *Osilinus/Phorcus* group (DONALD ET AL., 2012) recognizes nine species in a single genus *Phorcus* (older name than *Osilinus*), distributed from the Mediterranean Sea to the coasts of West Africa, mainland western Europe, Britain and Ireland and several Macaronesian Islands, including Madeira, Selvagens, Canaries and Cape Verde (it is absent from the Azores). The nine species (these authors consider each represents a divergent lineage) are the following: *P. richardi* (Payraudeau, 1826), *P. mutabilis* (Philippi, 1846), *P. articulatus* (Lamarck, 1822), and *P. turbinatus* (Born, 1778), from the Mediterranean, *P. lineatus* (Da Costa, 1778) and *P. sauciatus* (Koch, 1845), from Atlantic European coasts, the last extending to the northeastern African coast and to Madeira and Canary Islands, *P. atratus* (Wood, 1828), exclusive from Madeira and Canaries, *P. punctulatus* (Lamark, 1822), from Senegal (West Africa), and an additional species endemic to the Cape Verde Islands. The taxon *Osilinus atratus salvagensis* Talavera, 1978, from Selvagens Islands, was not included in the phylogenetic study of DONALD ET AL. (2012) and its taxonomic status should be clarified.

According to DONALD ET AL. (2012), the *Phorcus* species from the Cape Verde Islands, the mainland *P. lineatus*, from Atlantic European coasts, and *P. punctulatus*, from West Africa, are very close genetically. However, *P. punctulatus* and *P. lineatus* differ substantially in both colour pattern of the shell and geographic range. Shells of the former have a characteristic pattern of lines of white spots, which are absent in the later, and there is a geographical discontinuity between the two clades due to the long sandy coastline of southern Morocco and Mauritania. Consequently, if *P. lineatus* and *P. punctulatus* are considered to be separate species, then *Phorcus* sp. from Cape Verde must also be considered a different species since it is sister to the *punctulatus/lineatus* sister pair in the phylogeny obtained by DONALD ET AL. (2012).

The Cape Verde *Phorcus* species is a well-known and quite common topshell in the intertidal rocky coasts of this archipelago, previously identified as *Monodonta punctulata*, *M. tamsii* or *Osilinus atratus*. In the first faunal list of Cape Verde archipelago by ROCHEBRUNE (1881) this species appeared as *Monodonta punctulata*, and this author commented that it is the same species present in Senegal. NOBRE (1900) recorded this species under the name *Monodonta tamsi* Dunker, 1845, and the same name was employed by MARCHE-MARCHAD (1956). Latter, in the first monograph on the molluscan fauna of this archipelago, BURNAY & MONTEIRO (1977) used again the name *Monodonta punctulata* Lamarck, 1822, while NORDSIECK (1974) considered *Osilinus atratus* the species from Canary and Cape Verde Islands. GARCÍA-TALAVERA & BACALLADO (1981) repeated once more the name *M. tamsii* and, in opposition, COSEL (1982a, 1982b, 1982c) and BUYS (1991) used *M. punctulata* followed by GARCÍA-TALAVERA (1999). Finally, in recent monographs on the molluscs of the Cape Verde Islands by GUERREIRO & REINER (2000) and ROLÁN (2005) the names *Monodonta atrata* or *Osilinus atratus*, respectively, were used, and HERNÁNDEZ, ROLÁN & SWINNEN (2011) consider this species to be present in Madeira, Canaries and Cape Verde Islands.

Since the molecular data demonstrate that the Cape Verde *Phorcus* is a distinct species (DONALD ET AL. 2012), and if there is no available old name for it, it needs a name and should be described formally. That is the aim of this work. So, we complete here our previous paper on new species of Trochidae from the Cape Verde Archipelago (ROLÁN & TEMPLADO, 2001). The species here described is not rare and unknown, but a common and well-known species previously confused with others. Hence, it is now necessary to look for morpho-

logical characters that distinguish this undescribed species from the others of the same genus.

MATERIAL AND METHODS

Many shells and living specimens collected by the second author in several campaigns (now in the malacological collection of the Museo de Historia Natural de Santiago de Compostela) have been studied. In addition, the material of Atlantic species of the genus *Phorcus* in the malacological collection of the Museo Nacional de Ciencias Naturales of Madrid has been examined. Besides, Ramiro Fiadeiro collected in the Cape Verde Islands the studied live material of *Phorcus mariae* spec. nov., and Ramón Gómez provided specimens of *P. atratus* from Canaries for comparison.

Abbreviations:

MHNS= Museo de Historia Natural de Santiago de Compostela.
NHMUK= Natural History Museum of London.
MNCN= Museo Nacional de Ciencias Naturales, Madrid.
MNHN= Museum national d'Histoire naturelle, Paris.
s= empty shell.
spms= specimens with soft parts.

SYSTEMATIC PART

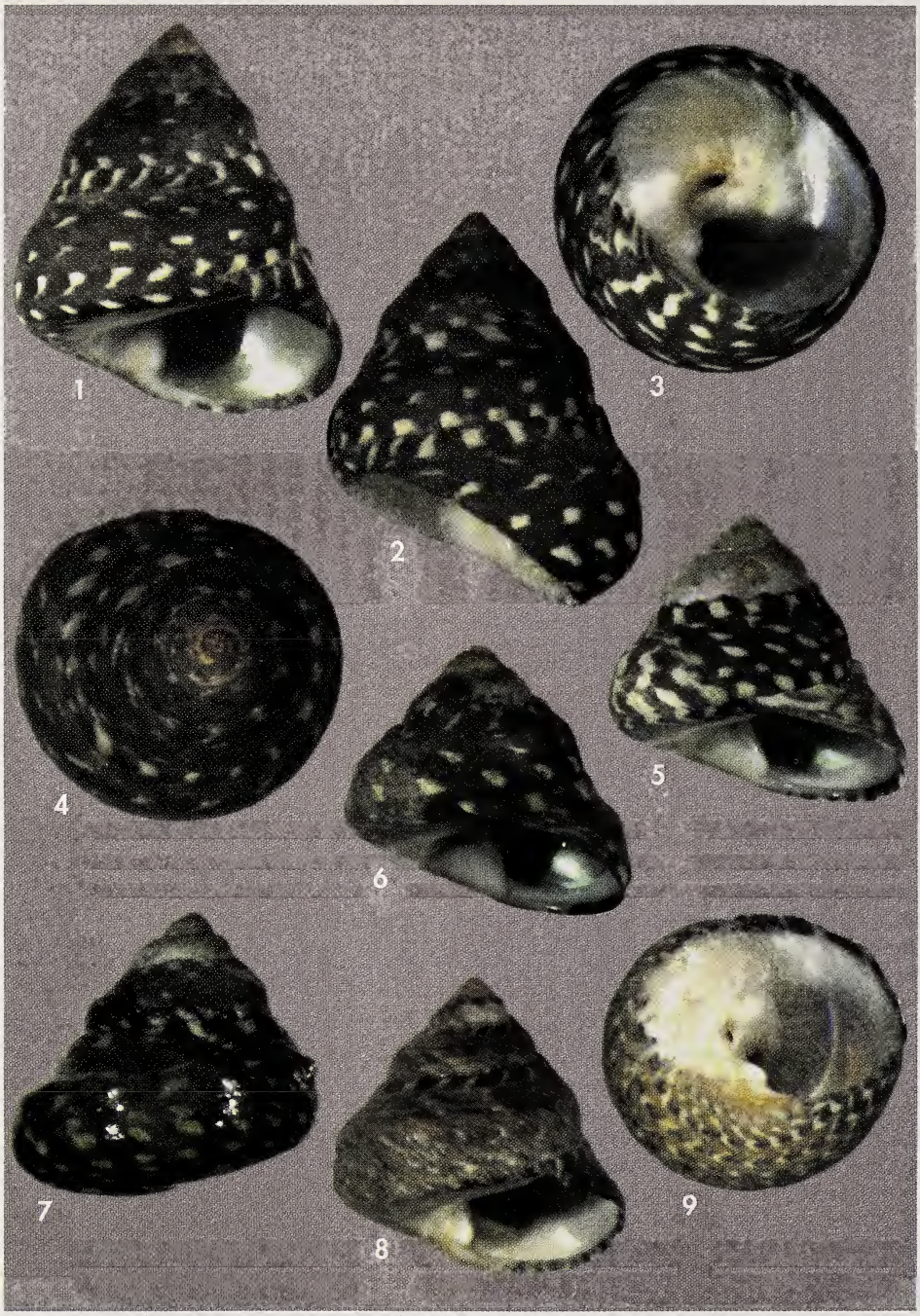
Genus *Phorcus* Risso, 1826
Phorcus mariae spec. nov. (Figs. 1-14, 19-21)

Type material: Holotype (s) (Figs. 1-4) and 10 paratypes (spms) (in MNCN, number 15.05/60049). Other paratypes in the following institutions: MNHN (25142, 10 spms), MHNS (100570, 5 spms), NHMUK(20120147-20120151, 5 spms), all from Sal-Rei y Ervatão, Boavista Island, Cape Verde Archipelago.
Other material examined: 5 spms from Maio (MHNS); 10 s from Santiago (MHNS); 12 s from Sal (MHNS), Cape Verde Islands; 55 s in three different boxes in the Hidalgo' collection (MNCN) from Cape Verde Islands (without specifying the particular locality or island), and originally identified as *Trochus tamsii* Dunker, 1858.
Type locality: Sal-Rei, Boavista Island, Cape Verde Archipelago.
Etymology: The name is after Maria Templado, daughter of the first author, for her constant support and companionship to both authors on many trips.

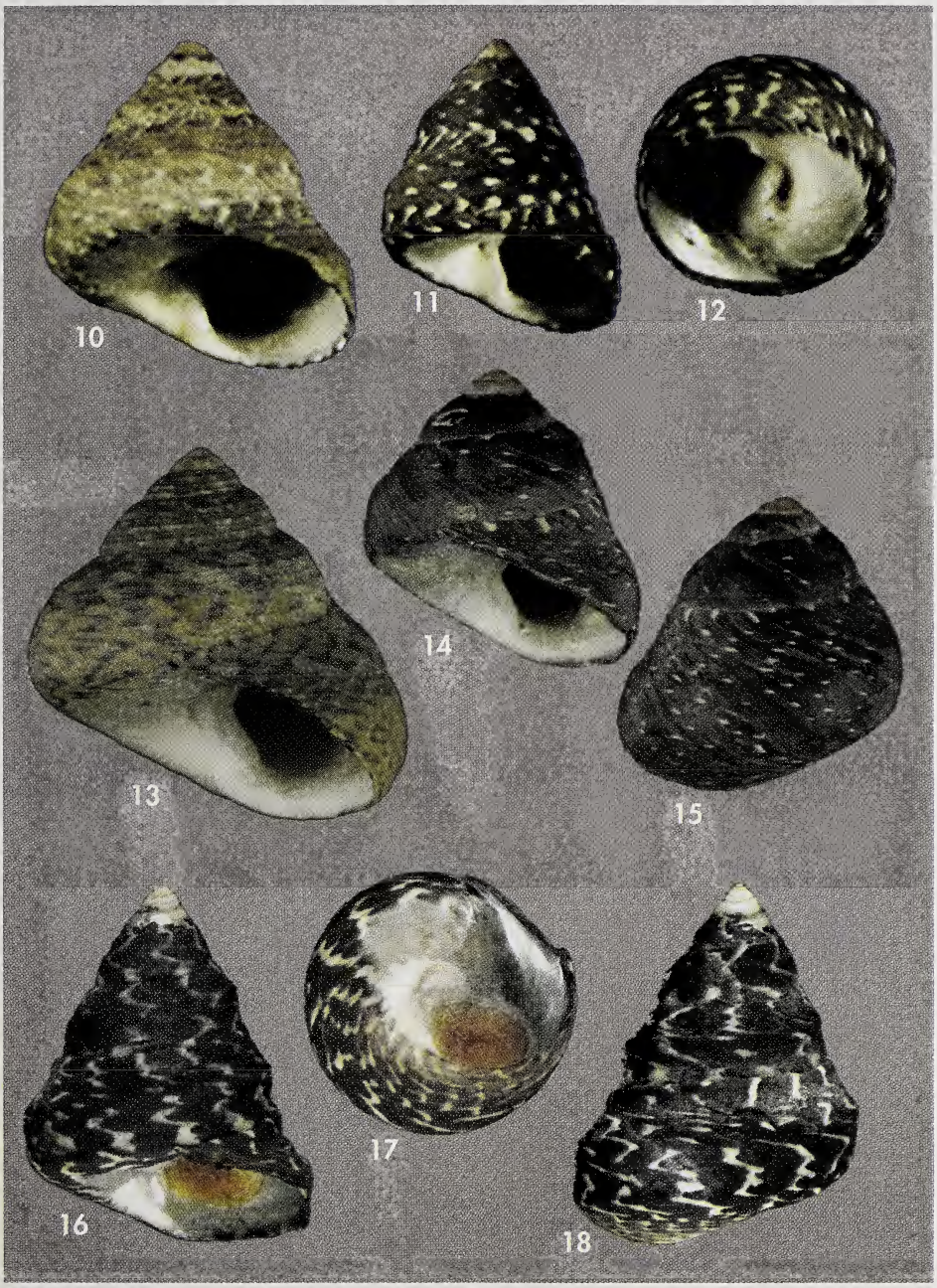
Description: Shell (Figs. 1-12) of medium size, trochiform, solid, not brilliant, dark in colour. Protoconch always strongly eroded in adult; examined in a juvenile (Fig. 19): it is whitish, with one whorl. Teleoconch begins with spiral cords separated by narrower interspaces. The adults have about 5 whorls, difficult to see due to erosion of the spire. The contour of the whorls forms a distinct sharp angle at about half the height of each whorl. The colour is dark, grayish brown, sometimes almost black, the base and the columella are white. Numerous and variable flame-like white stripes departing from the suture. Near the suture, a stronger cord is present, which is also regularly striped in white. The ovoid white blotches are clearly aligned spirally. Aperture wide, the external lip simple, sharp; interior iridescent; columella slightly prosocline, showing a quite elevated fold; umbilicus almost closed.

Dimensions: holotype 23.4 x 19.7 mm. The largest shells reach 25 mm in maximum dimension.

Soft parts of the animal (Fig. 20) with the head very dark (almost black). The lateral sides of the foot have a black background with minute orange tubercles aligned horizontally. The snout is almost black with dark orange lines. The base of the foot is dark green. The cephalic tentacles are black with lighter rings alternat-

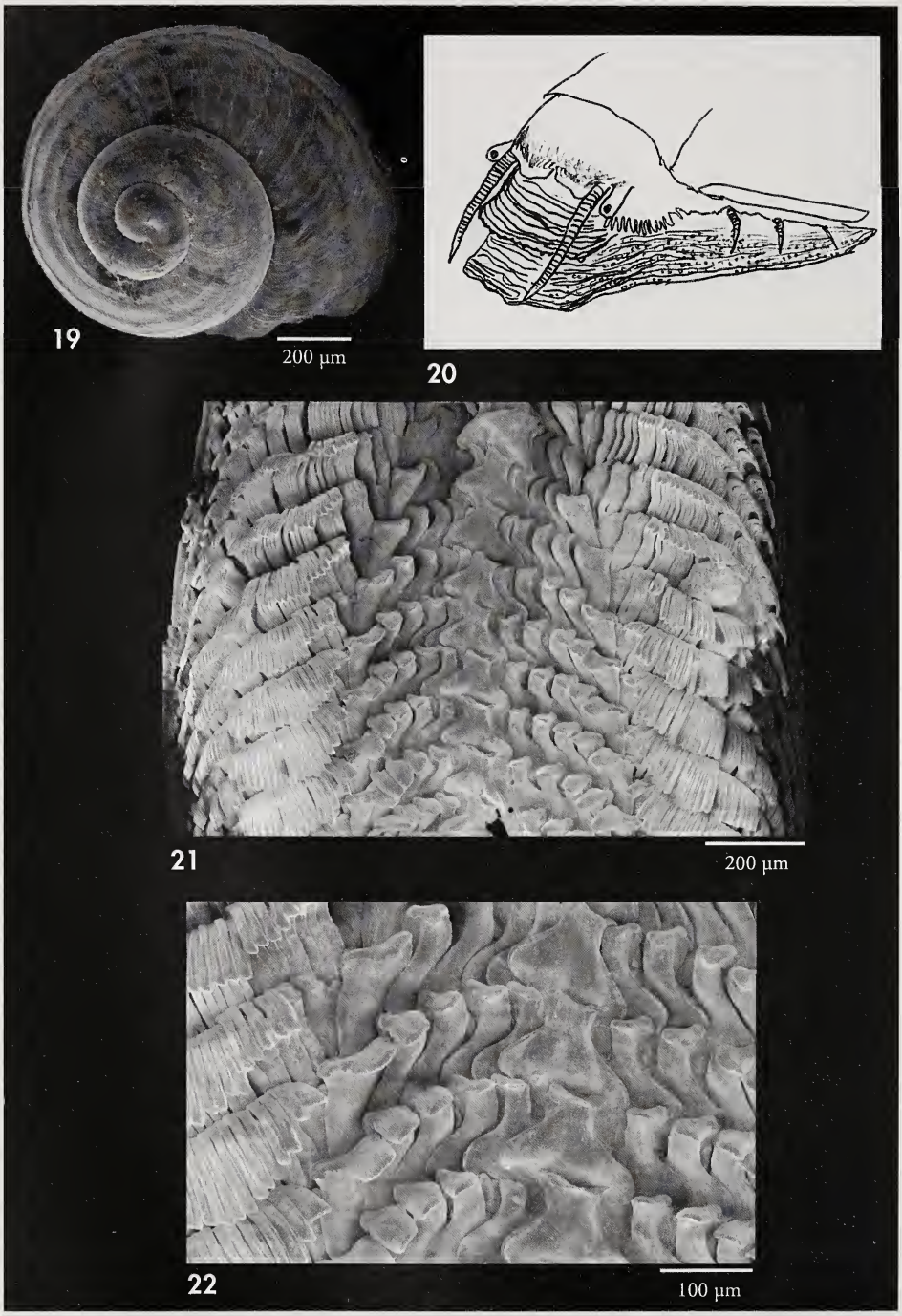


Figures 1-9. *Phorcus mariae* spec. nov. 1-4: holotype, 23.4 mm in height (MNCN); 5: paratype, 17.3 mm in height (NHMUK); 6: paratype, 15.4 mm (MNHN); 7: paratype, 16.8 mm (MNHN); 8-9: paratype, 18.3 mm (MNCN). All from Sal-Rei, Boavista, Cape Verde Islands.
Figuras 1-9. Phorcus mariae *spec. nov. 1-4: holotipo, 23,4 mm de altura (MNCN); 5: paratipo, 17,3 mm de altura (NHMUK); 6: paratipo, 15,4 mm (MNHN); 7: paratipo, 16,8 mm (MNHN), 8-9: paratipo, 18,3 mm (MNCN). Todos procedentes de Sal-Rei, Boavista, Islas de Cabo Verde.*



Figures 10-12. *Phorcus mariae* spec. nov. 10: shell from Santiago Is., 20.4 mm (MHNS); 11, 12: shells from Sal Is., 17.3 mm (MHNS). 13: *Phorcus lineatus* (Da Costa, 1778), 21 mm, Vigo (MHNS). Figures 14, 15. *Phorcus punctulatus* (Lamarck, 1822), 16.5 mm, Senegal (MHNS). Figures 16-18. *Phorcus atratus* (Wood, 1822), Gran Canaria, Canary Islands (MHNS).

Figuras 10-12. Phorcus mariae *spec. nov. 10: concha de la isla de Santiago, 20,4 mm (MHNS), 11-12. conchas de la isla de Sal, 17,3 mm (MHNS). 13:* Phorcus lineatus *(Da Costa, 1778), 21 mm, Vigo (MHNS). Figuras 14, 15.* Phorcus punctulatus *(Lamarck, 1822), 16,5 mm, Senegal (MHNS). Figuras 16-18.* Phorcus atratus *(Wood, 1822), Gran Canaria, Islas Canarias (MHNS).*



Figures 19-22. *Phorcus mariae* spec. nov. 19: protoconch and first teleoconch whorls (juvenile from Palhona, N of Sal, Cape Verde Islands); 20: drawing of the soft parts; 21, 22: radula and detail.
Figuras 19-22. Phorcus mariae *spec. nov. 19: protoconcha y primeras vueltas de la teleoconcha (ejemplar juvenil de Palhona, N de Sal, Cabo Verde), 20: dibujo de las partes blandas; 21, 22: rádula y detalle de la misma.*

ing. Cephalic lappets with dark orange colour; eyes outwards of the cephalic tentacles, at the extreme end of a wide pedunculus. Left neck lobe with between 13-18 digitiform prolongations. Right neck lobe almost smooth at its border. Three epipodial tentacles at each side.

Operculum multispiral, yellowish and with a central nucleus.

Radula (Figs. 21-22) like in other species of the genus *Phorcus*, with regularly arcuate tooth rows with rachidian and five lateral teeth of similar size and shape. The rachidian with narrow neck and reduced cusp.

Distribution: Known from all the islands of the Cape Verde Archipelago, living on rocky coasts at the high tidal level.

Remarks: Morphologically, the closest species is *Phorcus atratus* from Canary and Madeira Islands. Both species have a profile somewhat conical with angulose whorls, but *P. atratus* is relatively higher, darker, and the white stripes are arranged in a more or less zigzag pattern and nonaligned. *Phorcus punctulatus* (Lamarck, 1822), from the coast of West Africa, is more depressed, lacking any angulation on the whorls, which present a regular curvature. The white spots are small and are usually aligned obliquely. *Phorcus lineatus* (Da Costa, 1778), from the Atlantic European coasts, has also a regular convex curvature of the whorls lacking any angulation. Its colour has a gray-green background with irregular dark stripes and lacks any white spots of stripes.

A possible available older name for this species could be *P. tamsii* (Dunker, 1845). *Trochus tamsii* was described by Dunker in Philippi's "*Abbildungen und Beschreibungen*" (vol. 1 p. 189 and pl. 5 fig 3; the *Trochus* monograph is dated January, 1845). According to the original description its type locality is Luanda, where the genus does not exist despite quite extensive modern prospection. Once the type locality was misplaced and since in the narrative (TAMS, 1845) of the expedition it is said that they visited Madeira, but also S. Anton, in the archipelago of Cape Verdes, it cannot be ruled out that the specimens studied by Dunker came from these islands. Therefore, the option to restore the name *tamsii* for the Cape Verde species could be taken into account, instead of assigning a new name. However, since there is no certainty about the origin of the specimens studied by Dunker and because this name has been used interchangeably to refer to the *Phorcus* species of Cape Verde, Canaries and Madeira, we believed that it is more appropriate to consider the name of Dunker as a *nomen dubium*, presumably a senior synonym of *P atratus*, and propose a new name with a formal description of the species.

This new species is endemic to the Cape Verde Archipelago, which once again confirms the high rate of endemism among marine gastropods in these islands. In some taxa lacking a pelagic larval phase, there has been a major radiation with endemism in each of the islands, such us in the genera *Conus* (DUDA & ROLÁN, 2005; CUNHA, CASTILHO, RÜBER & ZARDOYA, 2005), *Rissoina* (ROLÁN & LUQUE, 2000) or *Euthria* (ROLÁN, 2005). On the other hand, some species with a short pelagic larval phase are found in all islands but they seem to be isolated from other archipelagos or from the west African mainland coast, such as this new topshell or the limpet *Patella lugubris* Gmelin, 1791, that is also present in the rocky intertidal of the Cape Verde Islands.

ACKNOWLEDGEMENTS

We thank Ramiro Fiadeiro who collected the live material of *Phorcus mariae* spec. nov. in the Cape Verde Islands, and Ramón Gómez who collected the specimens of *P. atratus* from Canaries for comparison. Jesús Méndez, of the Centro de Apoyo Científico y Tecnológico a la Investigación (CACTI) of the University of Vigo, made the micrographs of the protoconch and radula. J.T. was funded by the Spanish Ministerio de Educación y Ciencia (project CGL2007-60954).

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Reproductive cycle of *Scrobicularia plana* (da Costa, 1778) (Bivalvia: Semelidae) in two Moroccan lagoons: Khnifiss and Oualidia

Ciclo reproductor de *Scrobicularia plana* (da Costa, 1778) (Bivalvia: Semelidae) en dos lagunas marroquíes: Khnifiss y Oualidia

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ABSTRACT

The gametogenic cycle of *Scrobicularia plana* (da Costa, 1778) (Mollusca: Bivalvia) was studied in two Moroccan lagoons, both of them exposed to upwelling influence but with different climate and environmental characteristics (Oualidia located in Centre near an industrial area, and Khnifiss in saharian zone). The gonadal development was studied in both populations by histology and gonadic index. At both lagoons, the sex ratio averaged 2:1 in favor of females (at Oualidia, χ^2= 36.4150; df= 24; p= 0.05, and at Khnifiss, χ^2= 31.4104; df= 20; p= 0.05). The gametogenesis cycle began at Oualidia in September, while at Khnifiss in October. Two periods of spawning in spring and summer months were observed in both sites with small differences. Gonadic index never reached the value 1, and in the gonad of all individuals different stages of gametogenesis were found.

RESUMEN

El ciclo gametogénico de *Scrobicularia plana* (da Costa, 1778) (Mollusca: Bivalvia) fue estudiado en dos lagunas de Marruecos, ambas expuestas a la influencia de upwelling, pero con distintos climas y características ambientales (Oualidia situada en la parte mediana de la costa cerca de una zona industrial y Khnifiss en la zona sahariana). El desarrollo de las gónadas se ha estudiado en las dos poblaciones por histología y por el índice gonadal. En ambas lagunas, la proporción de sexos era en promedio 2:1 a favor de las hembras (en Oualidia, χ^2= 36,4150, df= 24, p= 0,05 y en Khnifiss, χ^2= 31,4104, df= 20, p= 0,05). El ciclo de gametogénesis comenzó en septiembre en Oualidia y en octubre en Khnifiss. Dos períodos de puesta en los meses de primavera y verano se observaron en ambos sitios con pequeñas diferencias. El índice gonádico nunca ha alcanzado el valor 1, y en la gónada de todos los individuos se han encontrado distintas etapas de la gametogénesis.

INTRODUCTION

The lagoons are part of coastal environments, and are among the most productive natural marine ecosystems but remain the weakest and most vulnerable because of natural and human effects. In Morocco, there are four lagoons, with

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different bio-ecological and climatic characteristics: Nador lagoon (on the Mediterranean coast) and Moulay Bousselham, Oualidia, and Khnifiss (located on the Atlantic coast). They have important ecological, biological and socio-cultural values, and are most important wetlands as stopover and wintering sites for thousands of migratory birds (Lakhdar Idrissi, Orbi, Zidane, Hilmi, Sarf, Massik and Makaoui, 2004).

The few studies realized on the Moroccan lagoons, have been limited in time and to some aspects: Chemical contamination (Cheggour, Chafik, Langston, Burt, Benbrahim and Texier, 2001), avifauna (Radi, Bergier, El Idrissi, Qninba, Zadane and Dakki, 2009; Zadane, Qninba, Ibn Tattou and Bergier, 2009), hydrology (Lakhdar Idrissi *et al.*, 2004).

In the last years, a multidisciplinary program (physical chemistry, structure of macrobenthic communities, pollutants, ecotoxicology and microbiology) has been carried out by our laboratory in two lagoons: Khnifiss and Oualidia (Idaradare, Chiffoleau, Moukrim, Alla, Auger, Lefrere and Rozuel, 2004). As a part of this research program, we have studied the reproductive cycle of : *Scrobicularia plana* (da Costa, 1778) an important and characteristic species of lagoon ecosystems.

Scrobicularia plana is a common intertidal sentinel species inhabiting soft substrata in estuaries and coastal areas from the Atlantic and the Mediterranean, with a wide range of distribution (Tebble, 1976). Because of this many studies have involved it (Paes-Da-Franca, 1956; Hughes, 1971; Worrall, Widdows and Lowe, 1983; Zwarts, 1991; Essink, Beukema, Coosen, Craeymeersch, Ducrotoy, Michaelis and Robineau, 1991; Sola, 1997; Guerreiro, 1998; Rodríguez de la Rúa, Prad, Romero and Bruzón, 2003; Raleigh and Keegan, 2006).

In Morocco, studies on the biology of *Scrobicularia plana* have concerned the dynamics of population monitoring (Kourradi, 1987; Cheggour, 1988; Bazairi, 1999). The reproductive cycle of *S. plana* was studied at the estuary of Oued Souss (Agadir) through histological studies (Bergayou, 2006).

In the present work, we study the reproductive biology of this species by histological techniques from two lagoons, Oualidia (northern industrial area) and Khnifiss (saharan zone), different by their climate and environmental characteristics, but both of them exposed to the influence of upwellings.

MATERIALS AND METHODS

Study sites (Fig. 1)

Oualidia lagoon (32° 44′ 42″ N, 9° 02′ 50″ W) is located between El Jadida and Safi in a highly industrialized urban area on the Atlantic coast. This lagoon is 7 km long and on average 0,5 km wide, and exchanges water with the ocean through a major inlet about 150 m wide and 2 m deep. Rainfall over the region accounts only for 1% of the fresh water entering the lagoon. The annual average rainfall, estimated from 1977 to 1998, is about 390 mm, with a maximum in December and no rain in the dry period from autumn (October) until spring. The drought began in June and continued until September. There are two large industrial complexes around this coast: Jorf Lasfar and Safi. Banaoui, Chiffoleau, Moukrim, Burgeot, Kaaya, Auger and Rozuel (2004) have reported a high contamination of Cd (29 μg/g dw) in *Perna perna* near the main discharges from these industrial complexes. Similar results were reported by Chafik, Cheggour, Cossa and Sifeddine (2001) who studied the contamination of *Mytilus galloprovincialis* in the same sites.

The Khnifiss lagoon (20 km long and 65 km2 surface area) is located between Tantan and Tarfaya (28° 02′ 54″ N, 12° 13′ 66″ W). It opens up into the Atlantic Ocean through a narrow inlet called "Foum Agoutrir", about 100 m wide. This lagoon, far from anthropogenic activity is part of the national biological and ecological reserve created on September 2006 (Parc National de Khnifiss, décret n° 2.06.461 of 26 September 2006).The lagoon is the only one located in the Saharian bioclimatic level. The water circulation to the lagoon is rich in nitrogen and phosphate components, especially during spring

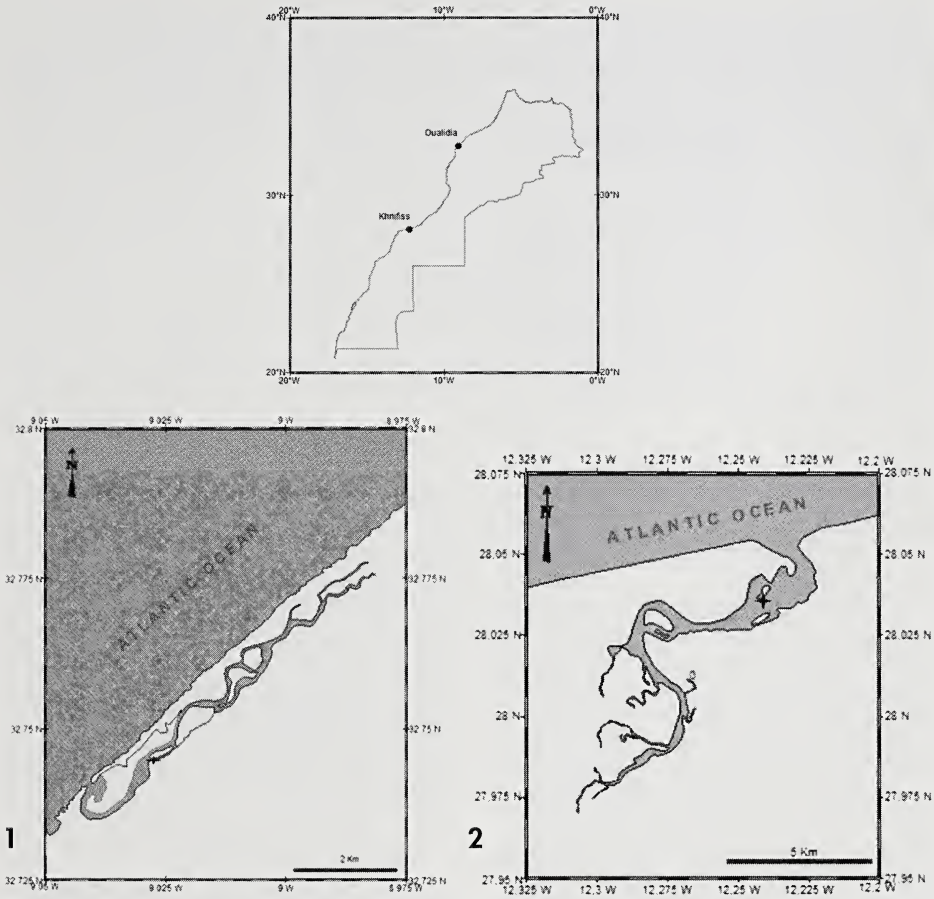

Figure 1: Location of the lagoons of Oualidia (1) and Khnifiss (2).
Figura 1: Situación de las lagunas de Oualidia (1) y Khnifiss (2).

tides. The high amount of chlorophyll in the lagoon is related to the presence of upwelling in the coastal area during spring and summer months. Previous studies have shown that the lagoon of Khnifiss is an environment recommended for shellfish (LAKHDAR IDRISSI *ET AL.*, 2004).

Sampling

Samples of *Scrobicularia plana* were collected from January 2005 to January 2006 in Oualidia, and Khnifiss, except January and September for the latter lagoon. Samples were taken in mud flats on a monthly frequence. Water temperature was recorded in each sampling period.

Reproductive cycle parameters studied

In total 905 specimens were sampled, 582 from Oualidia and 323 from Khnifiss (shell length 23 to 32 mm). For histological study of gonads, shells of *S. plana* were opened and soft parts were fixed in Bouin for 24 h. In the laboratory, the shell of each bivalve was removed and small pieces of soft parts were post-fixed in a new solution of Bouin. The central region of the foot was removed before being dehydrated through a graded series of ethanol and butanol, and finally embedded in wax. Sections 7 μm in thickness were then cut and stained with Hematoxilin of

Table I. Gametogenic scale used to determine histological stage of the gonadic developmental in *S. plana* according to LUBET (1959).
Tabla I. Escala gametogénica utilizada para determinar el estadio histológico de desarrollo de la gónada en S. plana, *según LUBET (1959).*

Stage	Brief description of gonad
Stage 0	Sexual rest
Stage I	Early gametogenesis
Stage IIID	Spent, completely empty lumina
Stage II	Actively developing gonads but mature gametes were not observed
Stage IIIA	Near ripe follicles with mature gametes
Stage IIIB	Spawning follicles distended
Stage IIIC	Partial spawning, partially empty lumina

Carazzii/ eosin (MARTOJA ET MARTOJA, 1967). The different stages of gonadal development were scored according to LUBET (1959) (Table I).

Quantitative analysis of the reproductive cycle was estimated from the gonadic index. This index (Seed, 1975) indicates the state of gonad maturity for each population and it is obtained from histological data. It was determined by giving a number to each of the gametogenic stages of LUBET (1959): stage 0 (number 1), stages I and II (number 2), stage IIIA (number 3), stages IIIB and IIIC (number 2) and stage IIID (number 1). For each sample of clams, the number of gonads showing a gametogenic stage is multiplied by the corresponding number. The figures obtained were then added and the sum was then divided by the total number of clams studied. This index broadly defines the reproductive condition of the population at any particular time. An increasing index in successive samples indicates that gonads are developing, while a falling index means that spawning is in progress.

RESULTS

Sex ratio

During this study, approximately 6.18% and 7.43% of the sampled population, at respectively Oualidia and Khnifiss, could not be sexed. The sex ratio was determined during the months of sexual activity, when the sexes are easily recognizable. In Oualidia, 546 specimens were analysed; the percentage of females and males was respectively 63 and 37 %. The sex ratio averaged 2:1 in favour of females (χ^2= 36.4150; df= 24; P= 0.05). At Khnifiss, a total of 299 individuals were analysed. The males represented 37.8 % and females 62.2 %. The sex ratio is in favour of females 2:1 (χ^2= 31.4104; df= 20; P= 0.05).

Gametogenic cycle

The distribution of the gametogenesis stages in *Scrobicularia plana* (both females and males) of Oualidia or Khnifiss lagoon, according to LUBET's scale (1959) is given in Figures 2 and 3. The gametogenic cycle of the populations from both sites shows few differences.

In clams from Oualidia lagoon, the stage 0 (sexual rest) and 1 (early gametogenesis) seems to begin from September (20% S0, 25% S1) to December (39.13% S1) in females. Developing gonads with mature gametes, stages II (16.67% in January) and IIIA (41.67% in May) occurred from January to August with peaks of spawning in both females and males. In this period, males from Oualidia were either ripe (IIIA stage) or in spawning (IIIB stage). From April to August, females were also either ripe or spawning. In males, we observed IIIC stage (17.64%) from April and IIID (33%) stage from May.

The population of Khinifiss showed stages 0 and 1 from October to December (as revealed in males). Some individuals in development of gonad were also found in this period. Stage IIIA (15%) was observed in early October and continued with important percentages of females until March (23%).Peaks of spawning (IIIB stage) occurred in August and November-December. The spawning of August was the most important in both females and males (50%). Increasing percentages of Stages IIIC and IIID have been observed from early April.

Gonadic index

In Oualidia lagoon, gonadic index shows increasing values from February to April (stage I and II). Principal spawning occurred in March which seems to be related to an increase in temperature levels. From April, there was a decrease in gonadic indices (stage IIIB) together with a decrease of sea water temperature. After spawning, a reconstruction of the gonad and additional spawning were observed, (optional periods of spawning were observed in September and November) (Figure 4).

In Khnifiss lagoon, gonadic index decreases between February and April, which corresponded to a spawning period and was coincident with a decrease of the temperature values. In July, when temperature levels increase, a further spawning event was recorded. The rest of the active period corresponds to reconstructions of the gonad and additional spawning.

In both sites, the gonadic index never reached 1. This shows that the resting period is reduced in *Scrobicularia plana* in Oualidia and Khnifiss lagoons.

Temperature

Figure 4 shows the variations of temperature along the sampling period. A similar temporal pattern was observed in both lagoons. The lowest values (15 °C) were observed in December whereas for the warm period (April-October), values were between 20 and 30°C. In Oualidia lagoon (Fig 4A), the temperature shows increasing levels from January to April. Another peak has been detected in October.

In Khnifiss lagoon, the temperature increases from February to April followed by a small decrease until July. Maximum value was also observed in August.

DISCUSSION

Over the course of our investigations the reproductive cycle of *Scrobicularia plana* was studied in Oualidia and Khnifiss lagoons. We have used specimens with shell length ranging between 20 and 32 mm (both sites considered). RALEIGH AND KEEGAN (2006) had reported that sexual maturity was attained at approximately 22 mm in shell length in Mweelon Bay (Galway, west coast of Ireland). A similar value was also reported by PAES-DA-FRANCA (1956), SOLA (1997) and GUERREIRO (1998). HUGHES (1971) observed that *S. plana* reaches sexual maturity in the second summer of life, in the animals with a shell length of 20 mm. RODRÍGUEZ DE LA RÚA *ET AL.* (2003) reported that the smallest size analyzed measured 23 mm in the Guadalquivir estuary (South West of Spain).

No hermaphroditic animals were observed during our study. HUGHES (1971), SOLA (1994) and RODRÍGUEZ DE LA RÚA (2003) obtained the same results, and established that *S. plana* is predominantly a dioecious species. However, PAES-DA-FRANCA (1956) reported a maximum of 4.42% showing this condition in a Portuguese population, and RALEIGH AND KEEGAN (2006) indicate one hermaphroditic condition in a Mweelon Bay (Galway, west coast of Ireland) population. Although this condition is rare in *S. plana*, LAMMENS (1967) indicates that it is usual to find a small number of hermaphrodite specimens in gonochoristic bivalve species, like in the case of *Anodonta cygnea* (Linné), *Mytilus edulis* (Linnaeus) and *Dreissena polymorpha* (Pallas).

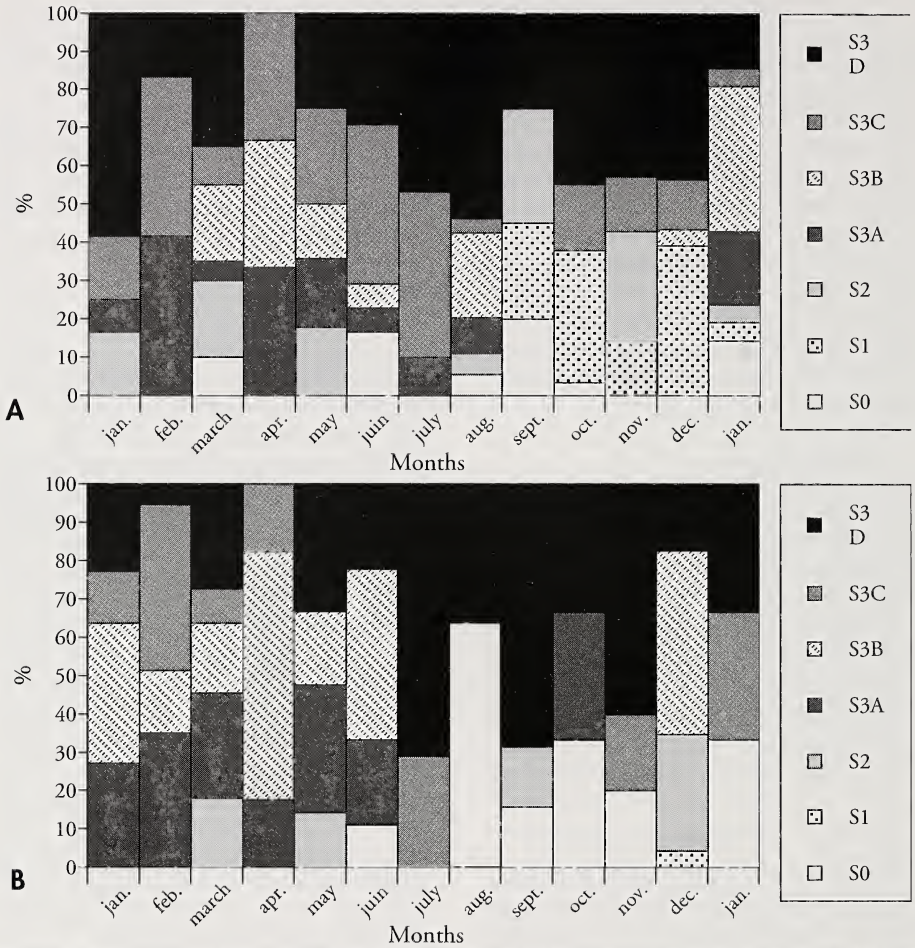

Figure 2. Percentage of occurrence of different stages of gametogenesis in *Scrobicularia plana* sampled from Oualidia lagoon (A: females; B: males). The cumulated frequencies of the different developmental stages corresponded to all bivalves studied (100%).

Figura 2. Porcentaje de ocurrencia de las diferentes etapas de la gametogénesis en Scrobicularia plana *muestreada en la laguna de Oualidia (A: hembras, B: machos). Las frecuencias acumuladas de las distintas etapas de desarrollo corresponden al total de los bivalvos estudiados (100%).*

At both lagoons, the overall sex ratio recorded by the current study indicates a predominance of females over males (at Oualidia: 63 % to 37 %, χ^2= 36.4150; df= 24; P= 0.05; at Khnifiss: 62.2 % to 37.8 %, χ^2= 31.4104; df= 20; P= 0.05). Otherwise, in other studies, Paes-da-Franca (1956) had also found a slightly higher number of females than males (1.2:1). By the same token, Raleigh and Keegan (2006) reported a rate of 1.1:1, but balanced it to 1:1.

In this study, we observed two principal periods of spawning in populations, the first in spring and the second in summer. In Oualidia lagoon, gonad development in *Scrobicularia plana* began in September (early autumn), and the spawning period began in March (spring). *S. plana* from this lagoon showed an extended period of gamete release, from March to August. Additional spawning periods have been recorded along the study period (espe-

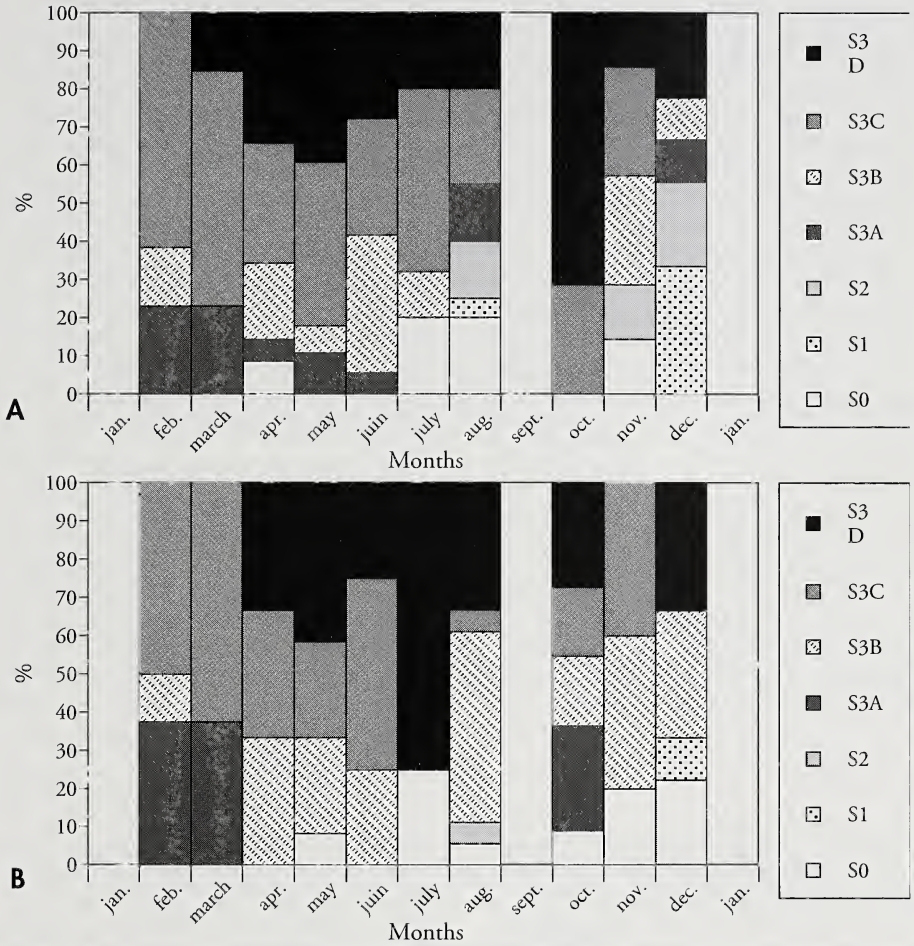

Figure 3. Percentage of occurrence of different stages of gametogenesis in *Scrobicularia plana* sampled from Khnifiss lagoon (A: females; B: males). The cumulated frequencies of the different developmental stages correspond to all bivalves studied (100%).

Figura 3. Porcentaje de ocurrencia de las diferentes etapas de la gametogénesis en Scrobicularia plana *muestreada en la laguna de Khnifiss laguna (A: hembras, B: machos). Las frecuencias acumuladas de las etapas de desarrollo diferentes corresponden al total de los bivalvos estudiados (100%).*

cially in September (late summer) and in November (autumn). In Khnifiss, the gonad development began in October and the spawning occurred in April and July (it seems that this is caused by an increase of temperature values). Active gametogenesis continued with reconstruction of gonad and additional spawning periods. Gonadic index never reached the value of 1, and all individuals were at various stages of gametogenesis evolution.

According to HUGHES (1971) and ESSINK *ET AL.*, (1991), the differences in the prolongation of the reproductive cycle of *S. plana*, would be due to latitudinal and thermal differences along the Atlantic coast (SOLA, 1997). At first, the start of gonad development is reached when mean temperature was an average of 20°C (Oualidia: 15°C to 25°C; Khnifiss: average of 20°C). In Spain, the start of gametogenesis coincided with an increase of temperature in the

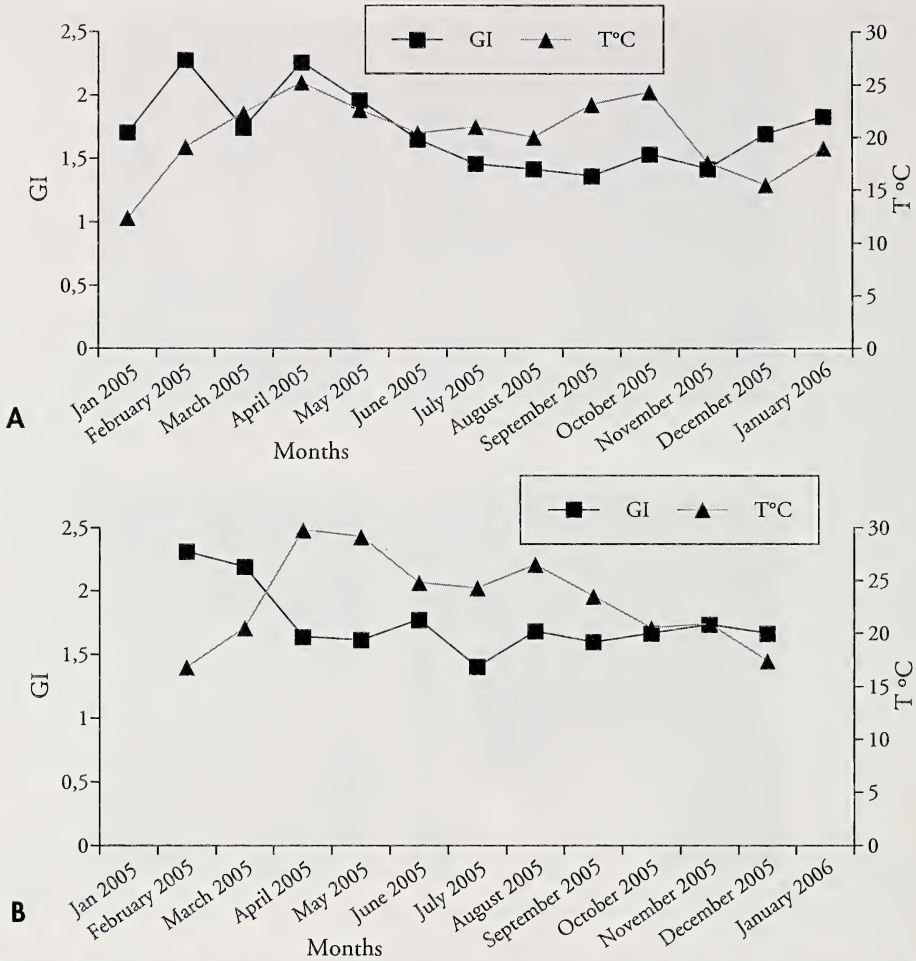

Figure 4. Variation of gonadic index (squares) and water temperature (triangles) throughout the study period. A: Oualidia; B: Khnifiss.

Figura 4. Variación del índice gonádico (cuadrados) y de la temperatura del agua (triángulos) durante el período de estudio. A: Oualidia; B: Khnifiss.

months of January (Sola, 1997) and February (Rodríguez de la Rua *et al.*, 2003). Hughes (1971), in his study in North Wales, found development of gonad to begin at a later date (April). Raleigh and Keegan (2006) found that gonad development began in January/February when the water and substrate temperature were, on average, 9°C.

Paes-da-Franca (1956), in a population of *Scrobicularia plana* of Portugal, found differentiated gametes in nearly all months of the year, except a short resting period in December with temperature of ca. 14 °C. The same result was reported throughout the current study, and we found differentiated gametes in all months of the sample period (except during the resting period). An increase of temperature at Oualidia could be responsible for the beginning of gametogenesis. The time available for gonadal development may decrease in relation to latitude increasing, until just beyond the geographical limit of the species.

According to several authors, *S. plana* is a species whose reproductive cycle varies with latitude (PAES-DA-FRANCA, 1956; HUGHES, 1971; BACHELET, 1981; GUERREIRO, 1998; RODRÍGUEZ DE LA RÚA *ET AL.*, 2003; and RALEIGH AND KEEGAN, 2006) with southern populations exhibiting more than one annual spawning period. Studies conducted in North Wales (HUGHES, 1971), northwest Spain (SOLA, 1997) and the west coast of Ireland (RALEIGH AND KEEGAN, 2006) recorded an increase in development from March onwards, spawning occurring from June to August and gonad regression in September. Studies carried out on Iberian populations (PAES-DA-FRANCA, 1956; GUERREIRO, 1998; RODRÍGUEZ DE LA RÚA *ET AL.*, 2003) reported two spawning periods. In Southern Spain, bivalve spawning periods are known to be longer due to latitudinal characteristics, which is consistent with the February to September spawning period proposed for *Solen marginatus* from Bajo de la Cabezuela (Bay of Cadiz, SW Spain) (BRUZÓN, RODRÍGUEZ DE LA RÚA, ROMERO AND PRADO, 2000): the first one occurring in spring and the second in summer. These results are similar to those found in Moroccan lagoons

WORRALL *ET AL.* (1983), who studied *S. plana* from three different estuaries in Southwest England, observed significant variations between local population, with differences in the timing and duration of the breeding cycle. It is attributed to food availability, suggesting that the shorter time window during which food was available at one site necessitated more rapid gamete development and caused earlier spawning. According to HUGHES (1971) and ESSINK *ET AL.* (1991), the differences in the prolongation of the reproductive cycle of *S. plana* would be due to latitudinal and thermal differences along the Atlantic coast (SOLA, 1997). PAES-DA-FRANCA (1956) and RODRÍGUEZ DE LA RÚA *ET AL.* (2003) observed that variations in the levels of chlorophyll "a" might affect the reproduction cycle of *S. plana*.

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Mollusques des milieux littoraux de la baie de Tunis

Moluscos de hábitats litorales de la bahía de Túnez

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RÉSUMÉ

Une liste de 194 espèces de mollusques est présentée comme résultat de l'échantillonnage mensuel de deux types d'habitat dans la baie de Tunis: les algues photophiles croissant sur les enrochements du littoral et les fonds meubles de la baie entre 3 et 4 m et entre 10 et 15 m. Parmi celles ci, il y a 7 espèces non-indigènes originaires soit de l'Indo-Pacifique, soit de l'Atlantique. Cinq espèces sont signalées ici pour la première fois sur le littoral tunisien: les gastéropodes pyramidellidés *Odostomia lukisii* Jeffreys, 1859 et *Chrysallida sigmoidea* (Monterosato, 1880), les bivalves *Musculus subpictus* (Cantraine, 1835), *Parvicardium scriptum* (Bucquoy, Dautzenberg et Dollfus, 1892) et *Abra nitida* (Müller, 1776). Des notes et des illustrations sont présentées pour quelques autres espèces remarquables recueillies dans cette campagne d'échantillonnage.
Les espèces recueillies sont en majorité des espèces à large répartition. Dans les algues, la majorité des espèces se trouvent dans l'ensemble de la Méditerranée et sur les côtes ibériques et marocaines de l'Atlantique; sur les fonds meubles, la plupart des espèces ont une distribution encore plus large,incorporant toute la Méditerranée mais aussi les côtes européennes et marocaines de l'Atlantique. La malacofaune des fonds meubles comprend aussi une part notable d'espèces de l'Atlantique tropical Ouest-Africain qui trouvent en Méditerranée leur limite naturelle de distribution. Contrairement à ce qui est établi en Méditerranée orientale, la contribution des espèces non-indigènes est modeste et leur origine est équilibrée entre l'Indo-Pacifique (4 espèces) et l'Atlantique (3 espèces).

RESUMEN

Una lista de 194 especies de moluscos se presenta como resultado de un muestreo mensual de dos tipos de hábitat en la bahía de Túnez: las algas fotófilas que crecen en los espigones de protección del litoral y sedimentos de la bahía de entre 3 y 4 m y entre 10 y 15 m. Hay siete especies no autóctonas que se originan en el Indo-Pacífico o el Atlántico. Cinco especies se citan aquí por primera vez en la costa tunecina: los gasterópodos piramidéllidos *Odostomia lukisii* Jeffreys, 1859 y *Chrysallida sigmoidea* (Monterosato, 1880), los bivalvos *Musculus subpictus* (Cantraine, 1835), *Parvicardium scriptum* (Bucquoy, Dautzenberg y Dollfus, 1892) y *Abra nitida* (Müller, 1776). Notas e ilustraciones se presentan sobre éstas y algunas otras especies de interés recogidas en esta campaña de muestreo.
La mayoría de las especies son de distribución amplia. En las algas, la mayoría de las especies se encuentran en todo el Mediterráneo y en las costas atlánticas de la Península Ibérica y Marruecos. En fondos blandos, la mayoría de las especies tienen una distribución aún más amplia, en todo el Mediterráneo y también en las costas europeas y marroquíes del Atlántico. La fauna de los fondos blandos también incluye una proporción significativa de especies del África Occidental que se encuentran en el límite natural de su distribución en el Mediterráneo. Contrariamente a lo que se conoce en el Mediterráneo oriental, la contribución de las especies no-autóctonas es pequeña y su origen está equilibrado entre el Indo-Pacífico (4 especies) y Atlántico (tres especies).

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INTRODUCTION

Au cours des dernières décennies, le niveau de connaissance de la faune marine méditerranéenne s'est notablement amélioré. De nombreuses espèces nouvelles pour la science ont été décrites, certaines nouvellement reconnues par l'emploi de nouveaux outils tels que les séquences moléculaires ou la microscopie électronique, d'autres simplement découvertes par la prospection de secteurs jusque là négligés. En Tunisie, malgré un inventaire global de la diversité biologique, visant à regrouper l'ensemble des données publiées, établi en 1997 par le Ministère de l'Environnement tunisien (Anonyme, 1997) et actualisé en 2004 (Afli, Ben Mustapha, Jarboui, Bradai, Hattour, Langar et Sadok, 2005), il reste encore beaucoup à faire pour mettre à jour les inventaires faunistiques locaux et régionaux en tenant compte des découvertes récentes et des classifications rénovées.

L'inventaire des espèces malacologiques des côtes tunisiennes repose largement sur les travaux du début du XXe siècle, en particulier ceux de Paul Pallary. Cette situation est bien différente du niveau de connaissance relativement complet que l'on a pour la faune de l'Europe du Nord-Ouest, où il y a moins d'espèces et un plus grand nombre de spécialistes et de travaux.

Des listes d'espèces de Mollusques marins de la Tunisie ont été publiées par Dautzenberg (1883, 1895), Pallary (1904-1906, 1914), Arnould (1955), Mars (1958), Ghisotti (1972), Fekih et Gougerot (1974), Rosso (1978), Enzenross et Enzenross (2001), Belkhodja (2003), Gharsallah-Haouas, Zamouri-Langar, Charef, Romdhane, Benmaiz et Gharsallah-Haouas (2004), Antit (2006); Antit, Gofas et Azzouna (2009), Cecalupo, Buzzurro et Mariani (2008), Ouannes-Ghorbel, Guirah, Boukrayaa, Elhasni, Derbali et Jarboui (2009). D'autres travaux citent des espèces de Mollusques dans le cadre d'études bionomiques: Chambost (1928), Seurat (1929a, 1929b, 1934), Molinier et Picard (1954), Pérès et Picard (1956), Gaillande (1970), Ktari-Chakroun et Azouz (1971), Azouz (1971, 1973), Zaouali (1978), Ayari et Afli (2003), Zamouri-Langar et al. (2004).

Un groupe de travail de l'Institut National des Sciences et Technologies de la Mer (INSTM) a passé en revue l'ensemble des travaux et études signalant des espèces marines dans les trois principales régions de la Tunisie, à savoir les golfes de Tunis, de Hammamet et de Gabès. Ces travaux ont abouti à une synthèse générale des travaux relatifs à la biodiversité marine en Tunisie (Afli et al. 2005). Dans cette synthèse, le total d'espèces de Mollusques recensées est de 416 pour le golfe de Tunis, 10 seulement pour le golfe de Hammamet et 171 pour le golfe de Gabès. Ces chiffres sont certainement à revoir à la hausse si l'on considère le nombre de 584 espèces de Mollusques citées par Cecalupo et al. (2008) pour le seul golfe de Gabès.

Dans le cadre plus général de la malacofaune méditerranéenne, les progrès des connaissances taxonomiques au cours des dernières décennies sont reflétés par l'apparition de catalogues constamment actualisés (CLEMAM : Check List of European Marine Mollusca www.somali.asso.fr/clemam/index.php et World Register of Marine Species <www. marinespecies. org> et assortis de références bibliographiques, qui serviront ici de cadre taxonomique.

Le présent travail a pour objectif général la caractérisation de la faune de Mollusques dans certains habitats représentatifs. Le choix du site de La Goulette, dans la baie de Tunis, a été guidé d'une part, par la présence, sur un espace réduit, de différents types d'habitats sur des substrats durs (enrochements avec couverture algale permanente et importante) et des substrats meubles (fonds sédimentaires et herbiers de Phanérogames); d'autre part, par le fait qu'il s'agit d'une zone sensible, située à proximité de l'agglomération urbaine de Tunis et du port, pour laquelle un suivi bionomique peut apporter des éléments essentiels pour une surveillance de la qualité de cet environnement pour une gestion rationnelle et durable.

Figure 1. Localisation des stations d'échantillonnage au niveau du golfe de Tunis. (K): canal Khéreddine, (1): station de substrat meuble à 3-4m de profondeur, (2): station de substrat meuble à 10-15m de profondeur; la flèche indique la station de substrat rocheux avec couverture d'algues. Image: Google Earth.

Figura 1. Ubicación de las estaciones de muestreo en el Golfo de Túnez. (K): Canal de Khereddine (1): Estación en fondos blandos de 3-4 m de profundidad, (2): Estación en fondos blandos de 10-15m de profundidad; la flecha indica la estación en sustrato rocoso con algas. Imagen: Google Earth.

MATÉRIEL ET MÉTHODES

Localisation des stations d'échantillonnage

Dans ce site de la Goulette, nous avons choisi trois stations, une pour les Algues sur les fonds durs (36°49,15'N, 10°18,60'E, 0-1 m), deux pour les fonds meubles: une station, entre 3-4 m de profondeur ((36° 49,1' N, 10° 18,9' E), et l'autre entre 10-15 m de profondeur (36° 49,1' N, 10° 19,6' E) (Figure 1).

Techniques de prélèvement

L'échantillonnage des algues a été réalisé mensuellement de février 2009 à février 2010. Pour le prélèvement, nous avons utilisé un cadre carré couvrant un quadrat de 25x25cm, soit une surface de 0,0625m², ce qui représente l'aire minimale d'échantillonnage de la malacofaune. Cinq répliques du quadrat d'Algues ont été récoltées pour chaque mois, soit un total de 65 prélèvements.

Pour l'étude des biocénoses des fonds meubles, le prélèvement des échantillons a été réalisé au moyen d'une petite drague de 72 × 30 cm d'ouverture, dont le bord inférieur est en dents de scie, est complétée par un filet avec une maille carrée de 3 × 3 mm. Les échantillonnages mensuels des fonds meubles ont été réalisés de mars 2009 à mars 2010, de jour, depuis une embarcation de pêcheur d'environ 5 m de longueur. Seul l'échantillon de mai 2009 a été nul à cause de problèmes avec l'embarcation. La durée est de chaque prélèvement est de 5 minutes avec une vitesse d'un nœud. Trois répliques ont été réalisées par station, pour donner une représentation des communautés

du fond, dont la distribution est en mosaïque.

Au laboratoire, les cinq filets contenant les Algues et la faune associée sont vidés chacun dans un grand volume d'eau douce afin de séparer la faune, et le résidu est tamisé en utilisant trois mailles différentes: 2- 1- 0,5 mm et sera ensuite trié sous la loupe binoculaire. La récolte ramenée par la drague est lavée sur une série de tamis de maille décroissante (10mm- 5mm- 2mm- 1mm et 0,5mm). En dessous de cette taille, on considère que l'on ne perd pratiquement aucune espèce de Mollusque, la fraction contenant principalement des juvéniles des espèces de plus petite taille.

Pour le processus d'identification des espèces, nous avons recours à plusieurs ressources:

- Une collection à la Faculté des Sciences de Tunis qui a été collectée au cours de nos recherches de mastère (Antit, 2006): elle nous a permis la séparation des espèces par famille en utilisant la clé élaborée à cette occasion (Antit et Azzouna, 2008).

- La collection malacologique du Laboratoire d'Invertébrés Marins du Département de Biologie Animale de l'Université de Malaga; qui nous a permis l'identification de la plupart des espèces méditerranéennes exotiques.

- Des ouvrages de détermination (Tebble, 1966; Giannuzzi-Savelli, Pusateri, Palmeri et Ebreo, 1994, 1997, 1999, 2003; Giannuzzi-Savelli, Pusateri, Palmeri, Ebreo, Coppini, Margelli et Bogi, 2001; Cossignani et Ardovini, 2011; Gofas, Moreno et Salas, 2011) ainsi que les nombreux articles de revues.

RÉSULTATS

Nombre et proportions des groupes de Mollusques récoltés

L'échantillonnage mensuel des algues photophiles et des deux stations de fonds meubles a livré un total de 40271 spécimens dans les stations étudiées à la Goulette, parmi lesquels nous avons pu identifier 194 espèces.

Sur le plan quantitatif (Fig. 2), la classe des Gastéropodes est largement dominante par le nombre d'espèces (125 espèces, 64,4% du total) mais la proportion est équilibrée entre les Gastéropodes (49,7%) et les Bivalves (48,9%). du point de vue du nombre d'individus. Les classes des Scaphopodes et des Polyplacophores apportent une contribution mineure. Dans les échantillons des algues photophiles, les Gastéropodes sont le groupe le plus important tant par le nombre d'espèces (70,96%) que par le nombre d'individus (71,59%). En revanche, dans les fonds meubles, les Gastéropodes sont majoritaires en nombre d'espèces (55,37% à 3-4 m, 57,52% à 10-15 m) mais les Bivalves apportent les effectifs les plus importants (63,68% à 3-4 m, 61,80% à 10-15 m).

Inventaire des espèces identifiées dans les différents échantillons

Les espèces benthiques inventoriées dans la présente étude sont pour la plupart déterminées jusqu'au niveau spécifique. Dans deux cas, les juvéniles de deux espèces sont morphologiquement indiscernables et ont été comptabilisés comme un taxon du niveau famille. Ceci s'applique d'une part aux juvéniles de *Bolinus brandaris* et *Hexaplex trunculus*, que nous n'avons pas réussi à séparer à une taille inférieure 5 mm et comptabilisés alors comme « Muricidae »; d'autre part à des juvéniles probables de *Loripes* comptabilisés comme « Lucinidae ». Ces taxa entrent dans les calculs quantitatifs portant sur le nombre d'individus, mais ne sont pas comptés comme une espèce dans les données de richesse spécifique

Quatre autres espèces n'ont pas été identifiées au niveau spécifique. Il s'agit d'une espèce de Rissoidés du genre *Pusillina* qui sera étudiée séparément, d'une espèce du genre *Odostomia* représentée seulement par quelques individus et de deux Opisthobranches appartenant aux genres *Runcina* et *Doto*. On connaît actuellement en Méditerranée 17 espèces de *Runcina* et 16 espèces de *Doto*, dont la diagnose spécifique se base entre autres sur des patrons de colora-

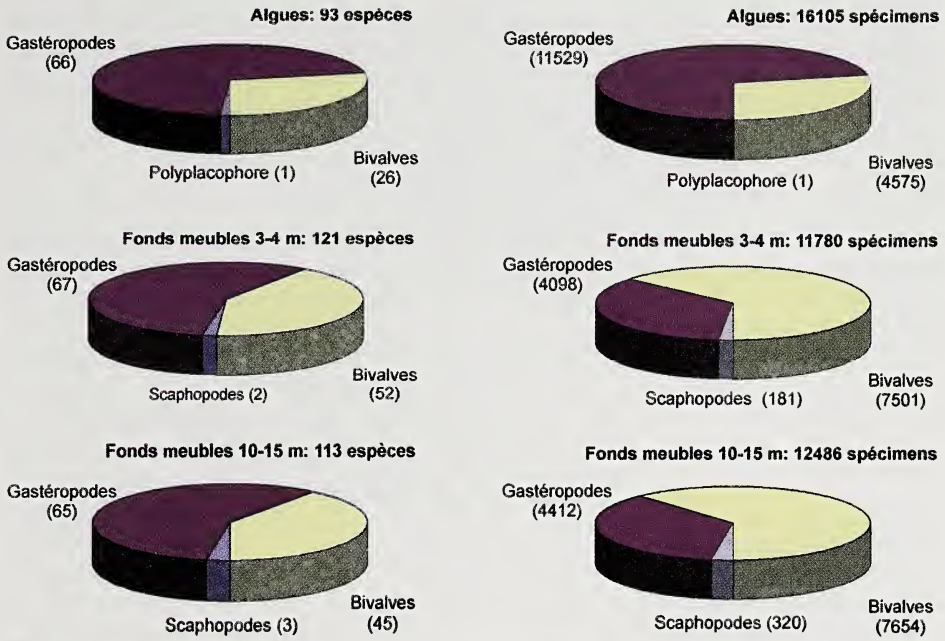

Figure 2. Proportions des différents groupes systématiques de mollusques en fonction du nombre des espèces (colonne de gauche) et du nombre des spécimens (colonne de droite) dans les trois séries d'échantillons.

Figura 2. Proporciones de los diferentes grupos sistemáticos de moluscos en función del número de especies (columna de la izquierda) y el número de individuos (columna de la derecha) en las tres series de muestras.

tion qui doivent être observés sur le vivant ou sur des photographies d'exemplaires vivants.

Le Tableau I donne une liste de ces espèces, dans l'ordre de la classification systématique, les effectifs recueillis dans chacune des séries d'échantillons, ainsi que les attributs biogéographiques. Les espèces non-indigènes, qui sont au nombre de 7, ont fait l'objet d'un travail séparé (ANTIT, GOFAS, SALAS ET AZZOUNA, 2011) et ne seront pas discutées de nouveau ici. Certaines espèces qui sont signalées pour la première fois en Tunisie, ou présentent des problèmes particuliers quant à leur détermination, seront en revanche discutées à la suite de la liste.

Affinités biogéographiques des espèces

La majorité des espèces de la malacofaune (71%) possède une répartition assez étendue, comprenant l'ensemble de la Méditerranée et une aire plus ou moins grande dans l'Atlantique (Fig. 3). Si l'on considère le nombre d'individus, la prépondérance de ces espèces à large répartition est encore plus forte (82%). Il s'agit donc:

- soit d'espèces dites « lusitaniennes », s'étendant dans le golfe Ibéro-Marocain,
- soit d'espèces qui atteignent vers le nord une grande partie des côtes européennes, en général jusqu'aux Iles Britanniques et souvent jusqu'à la Scandinavie,
- soit encore d'espèces à affinité tropicale ayant une répartition importante en Afrique Occidentale.

Les endémiques méditerranéens stricts (espèces ne dépassant pas le Détroit de Gibraltar vers l'Ouest, Alb+Med sur la Figure 3) représentent un quart des espèces, en accord avec le

Tableau I. Liste faunistique des espèces de mollusques de la baie de Tunis (faune des algues, des sédiments de 3-4 m et des sédiments de 10-15 m) dans les échantillons quantitatifs. Les chiffres des colonnes 2, 3 et 4 représentent le total des individus recueillis vivants dans chacun des ensembles d'échantillons, et servent de base pour les diagrammes des Figures 2 et 3. Les espèces dont le nom apparaît en gras sont illustrées et détaillées ci-dessous. Souligné: nouvelle signalisation pour la Tunisie à partir de cette série de récoltes. * dénote les espèces non-indigènes.
*Tabla I. Lista de especies de fauna de moluscos de la bahía de Túnez (fauna de las algas, de los sedimentos y de los sedimentos en 3-4 m y en 10-15 m) en las muestras cuantitativas. Los números en las columnas 2, 3 y 4 son el total de los individuos recogidos vivos en cada serie de muestras, y constituyen la base de los diagramas de las Figuras 2 y 3. Las especies cuyo nombre aparece en negrita están ilustradas y comentadas más adelante. Subrayado: nueva cita para Túnez a partir de esta campaña de muestreo. * denota especies no autóctonas.*

	Algues sur rochers 0-1m	Fonds meubles 3-4m	Fonds meubles 10-15m	Méditerranée hors Alboran	Mer d'Alboran	Golfe ibero-Marocain	Atlantique Européen	Autres
EMBRANCHEMENT DES MOLLUSQUES								
Classe des POLYPLACOPHORES								
Famille ACANTHOCHITONIDAE Pilsbry, 1893								
Acanthochitona crinita (Pennant, 1777)	1			x	x	x	x	
Classe des GASTÉROPODES								
Famille PATELLIDAE Rafinesque, 1815								
Patella caerulea Linné, 1758	9			x	x			
Famille FISSURELLIDAE Fleming, 1822								
Fissurella nubecula (Linné, 1758)	310			x	x	x		
Diodora graeca (Linné, 1758)	20			x	x	x	x	
Famille TROCHIDAE Rafinesque, 1815								
Gibbula racketti (Payraudeau, 1826)	1674	20		x	x	x		
Gibbula leucophaea (Philippi, 1836)		1		x				
Gibbula adansonii (Payraudeau, 1826)	2		1	x				
Gibbula umbilicaris (Linné, 1758)	2			x	x	x		
Osilinus articulatus (Lamarck, 1822)	1			x	x			
Osilinus turbinatus (Born, 1778)	2			x	x			
Famille PHASIANELLIDAE Swainson, 1840								
Tricolia speciosa (von Mühlfeldt, 1824)	23	22	10	x				
***Tricolia miniata* (Monterosato, 1884)**	1863	6		x	x	x		
Tricolia pullus (Linné, 1758)		2		x	x	x	x	
Famille NERITIDAE Rafinesque, 1815								
Smaragdia viridis (Linné, 1758)		34	7	x	x	x		
Famille LITTORINIDAE Children, 1834								
Echinolittorina punctata (Gmelin, 1791)	1			x	x	x		Mauritanie-Sénégal
Melarhaphe neritoides (Linné, 1758)	3			x	x	x	x	
Famille RISSOIDAE Gray, 1847								
Rissoa auriscalpium (Linné, 1758)		1	4	x				
Rissoa guerinii Récluz, 1843	1			x	x	x	x	
Rissoa monodonta Philippi, 1836		9		x				
Rissoa membranacea (J. Adams, 1800)		41	44	(x)	x	x	x	

Tableau I. Suite.
Tabla I. Continuación.

	Algues sur rochers 0-1m	Fonds meubles 3-4m	Fonds meubles 10-15m	Mediterranée hors Alboran	Mer d'Alboran	Golfe ibero-Marocain	Atlantique Européen	Autres
Rissoa oblonga Desmarest, 1814		8		x				
Rissoa similis Scacchi, 1836	1574	52	14	x	x	x		
Pusillina lineolata (Michaud, 1832)			4					
Pusillina inconspicua (Alder, 1844)	1	326	326	x	x	x	x	
Pusillina sp.	66	313	79					
Pusillina philippi (Aradas & Maggiore, 1844)	102	42	61	x	x			
Setia amabilis (Locard, 1886)	24			x	x			
Setia turriculata Monterosato, 1884	15			x	x	x		
Crisilla semistriata (Montagu, 1808)	85	2		x	x	x	x	
Crisilla tenera (Philippi, 1844)		1	9	x	x	x		
***Alvania mamillata* Risso, 1826**	91			x	x			
Alvania subcrenulata (B.D.D., 1884)	17	1		x	x			
Alvania montagui (Payraudeau, 1826)	267	1		x	x			
Alvania geryonia (Nardo, 1847)		1		x				
Manzonia crassa (Kanmacher, 1798)	2			x	x	x	x	
Rissoina bruguieri (Payraudeau, 1826)			3	x				
Famille ANABATHRIDAE Keen, 1971								
Pisinna glabrata (von Mühlfeldt, 1824)	814			x	x			Açores
Famille CAECIDAE Gray, 1850								
Caecum trachea (Montagu, 1803)	4			x	x	x	x	
Parastrophia asturiana de Folin, 1870	2			x	x	x		
Famille TORNIDAE Sacco, 1896								
Circulus striatus (Philippi, 1836)		2		x	x	x	x	
Famille IRAVADIIDAE Thiele, 1928								
Hyala vitrea (Montagu, 1803)			3	x	x	x	x	
Famille CERITHIIDAE Fleming, 1822								
* *Cerithium scabridum* Philippi, 1848	317			(x)				Mer Rouge
***Cerithium repandum* Monterosato, 1878**	64			x				
Bittium reticulatum (da Costa, 1778)	1851	452	723	x	x	x	x	
Famille CERITHIOPSIDAE H. et A. Adams, 1853								
Cerithiopsis tubercularis (Montagu, 1803)	1		x	x	x	x		
Famille TURRITELLIDAE Lovén, 1847								
Turritella communis (Risso 1826)			1	x	x	x	x	
Famille CALYPTRAEIDAE Lamarck, 1809								
Crepidula moulinsii Michaud, 1829		2	3	x				
Famille VERMETIDAE Rafinesque, 1815								
Vermetus rugulosus Monterosato, 1884	75			x	x			
Vermetus granulatus (Gravenhorst, 1831)	27			x	x			
Famille EULIMIDAE Philippi, 1853								
Eulima glabra (da Costa 1778)			4	x	x	x	x	
Melanella petitiana (Brusina, 1869)			1	x	x	x	x	

Tableau I. Suite.
Tabla I. Continuación.

	Algues sur rochers 0-1m	Fonds meubles 3-4m	Fonds meubles 10-15m	Mediterranée hors Alboran	Mer d'Alboran	Golfe ibero-Marocain	Atlantique Européen	Autres
Melanella praecurta (Pallary, 1904)	1							
Melanella lubrica (Monterosato, 1890)		1		x	x	x		
Famille EPITONIIDAE Berry, 1910								
Epitonium tenuicostatum (Sowerby, 1844)			1	x	x	x	x	
Famille NATICIDAE Guilding, 1834								
Neverita josephinia Risso, 1826		191	103	x				
Natica millepunctata Lamarck, 1822			3	x				
Payraudeautia intricata (Donovan, 1804)			1	x	x			
Famille MURICIDAE Rafinesque, 1815								
Bolinus brandaris (Linné, 1758)		48	52	x	x	x		
Hexaplex trunculus (Linné, 1758)	24	383	320	x	x	x		
Muricidae (juvéniles *B. b.* ou *H.t.*))		38	221					
Ocenebra erinaceus (Linné, 1758)	87			x	x	x	x	
Ocinebrina edwardsii (Payraudeau, 1826)	78			x	x	x		
Famille NASSARIIDAE Iredale, 1916								
Nassarius mutabilis (Linné, 1758)		460	538	x	x			
Nassarius corniculum (Olivi, 1792)	453			x	x	x		
Nassarius pygmaeus (Lamarck, 1822)		304	469	x	x	x	x	
Nassarius cuvierii (Payraudeau, 1826)	41	24	3	x	x	x		
Nassarius unifasciatus (Kiener, 1834)		2	16	x				
Nassarius incrassatus (Ström, 1768).	10	18	6	x	x	x	x	
Famille FASCIOLARIIDAE Gray, 1853								
Fusinus syracusanus (Linné, 1758)		50	33	x				
Famille BUCCINIDAE Rafinesque, 1815								
Pollia dorbignyi (Payraudeau, 1826)		11	5	x	x			
Pollia scacchiana (Philippi 1844)			1	x				
Famille COLUMBELLIDAE Swainson, 1840								
Columbella rustica (Linné, 1758)	162	106		x	x	x		
* *Mitrella psilla* (Duclos, 1846)	362		1					Ouest Afrique
Famille CYSTISCIDAE Stimpson, 1865								
Gibberula miliaria (Linné, 1758)	125	2		x	x	x		
Gibberula philippii (Monterosato, 1878)		3		x	x			
Famille MARGINELLIDAE Fleming, 1828								
Granulina marginata (Bivona, 1832)		2	1	x	x			
Volvarina mitrella (Risso, 1826)		1		x				
Famille CLAVATULIDAE Gray, 1853								
Fusiturris undatiruga (Bivona Ant. 1838)		19	23	x	x	x		Ouest Afrique
Famille MANGELIIDAE P. Fischer, 1883								
Mangelia paciniana (Calcara, 1839)	9			x	x			
Mangelia attenuata (Montagu, 1803)		4	8	x	x	x	x	
Mangelia unifasciata Deshayes, 1835		53	40	x	x	x		
Mangelia multilineolata (Deshayes, 1835)	14	1		x	x			

Tableau I. Suite.
Tabla I. Continuación.

	Algues sur rochers 0-1m	Fonds meubles 3-4m	Fonds meubles 10-15m	Méditerranée hors Alboran	Mer d'Alboran	Golfe ibero-Marocain	Atlantique Européen	Autres
Bela zonata (Locard, 1892)		17	25	x	x	x		
Bela zenetouae van Aartsen, 1988		3	5	x				
Bela brachystoma (Philippi, 1844)			3	x	x	x	x	
Famille CONIDAE Fleming, 1822								
Conus mediterraneus (Bruguière, 1792)	38	14	14	x	x	x		
Famille CIMIDAE Warén, 1993								
Graphis albida (Kanmacher, 1798)	10			x	x	x	x	
Famille OMALOGYRIDAE G.O. Sars.1878								
Omalogyra atomus (Philippi, 1841)	111			x	x	x	x	
Ammonicera fischeriana (Monterosato, 1869)	144			x	x	x	x	
Famille PYRAMIDELLIDAE Gray, 1840								
Odostomia conoidea (Brocchi, 1814)	1	47	63	x	x	x	x	Ouest Afrique
Odostomia plicata (Montagu, 1803)	2			x	x	x	x	
***Odostomia lukisii* Jeffreys, 1859**	13			x	x	x	x	
***Odostomia kromi* van Aartsen, Menkhorst & Gittenberger, 1984**	47			(x)	x	x		
Odostomia sp.			2					
***Chrysallida sigmoidea* (Monterosato, 1880)**		10	45	(x)	x	x		Ouest Afrique
Chrysallida fenestrata (Jeffreys, 1848)	1	6	23	x	x	x	x	
***Chrysallida juliae* (de Folin, 1872)**			24	x	x	x		Mauritanie-Sénégal
***Chrysallida terebellum* (Philippi, 1844)**		68	85	x	x	x	x	
Famille PYRAMIDELLIDAE Gray, 1840 (suite)								
***Chrysallida indistincta* (Montagu, 1808)**		1	9					
Chrysallida emaciata (Brusina, 1866)	2			x	x			
Chrysallida brusinai (Cossmann, 1921)	1			x	x	x		Ouest Afrique
Chrysallida excavata (Philippi, 1836)			4	x	x	x	x	Ouest Afrique
Noemiamea dolioliformis (Jeffreys, 1848)	1			x	x	x	x	
Turbonilla rufa (Philippi, 1836)		5	23	x	x	x	x	
Turbonella crenata (Brown, 1827)		13	6	x	x	x	x	
Turbonilla delicata (Monterosato, 1874)		10	69	x	x	x	x	
Turbonilla gradata B.D.D., 1883	1	5	14					
Eulimella acicula (Philippi, 1836)		3		x	x	x	x	
Famille MURCHISONELLIDAE Casey, 1905								
Ebala pointeli (de Folin, 1868)		5	29	x	x	x		Ouest Afrique
Famille ACTAEONIDAE d'Orbigny, 1842								
Acteon tornatilis (Linné, 1758)		5	10	x	x	x	x	
Famille RINGICULIDAE Philippi, 1853								
Ringicula auriculata (Ménard, 1811)			1	x	x	x		
Ringicula conformis Monterosato, 1877		1	3	x	x	x		Ouest Afrique
Famille RETUSIDAE Thiele, 1925								
Retusa minutissima (Monterosato, 1878)		78	66	x	x			
Retusa truncatula (Bruguière, 1792)	16			x	x	x	x	

Tableau I. Suite.
Tabla I. Continuación.

	Algues sur rochers 0-1m	Fonds meubles 3-4m	Fonds meubles 10-15m	Mediterranée hors Alboran	Mer d'Alboran	Golfe ibero-Marocain	Atlantique Européen	Autres
Pyrunculus hoernesii (Weinkauff, 1866)	1			x	x	x		
Cylichnina umbilicata (Montagu, 1803)			3	x	x	x	x	
Famille RHIZORIDAE Dell, 1952								
Volvulella acuminata (Bruguière, 1792)			1	x	x	x		Ouest Afrique
Famille PHILINIDAE Gray, 1850								
Philine catena (Montagu, 1803)	46			x	x	x	x	
Philine quadripartita Ascanius, 1772		5	12	x	x	x	x	
Famille HAMINOEIDAE Pilsbry, 1895								
Haminoea orbignyana (Férussac, 1822)	406	2		x	x	x		
Haminoea hydatis (Linné, 1758)	3	1		x	x	x	x	
Weinkauffia turgidula (Forbes, 1844)		4	6	x	x			
Famille BULLIDAE Gray, 1827								
Bulla striata Bruguière, 1792	1	3	2	x	x	x		Ouest Afrique
Famille PLAKOBRANCHIDAE Rang, 1829								
Elysia viridis (Montagu, 1804)	2			x	x	x	x	
Famille POLYCERIDAE Alder et Hancock, 1845								
* *Polycerella emertoni* Verill, 1881	1	713	657	x	x	x		Est États-Unis
Famille RUNCINIDAE H. et A. Adans, 1854								
Runcina sp.	6							
Famille DOTIDAE Gray, 1853								
Doto sp.		18	66					
Classe des *BIVALVES*								
Famille NUCULIDAE Gray, 1824								
Nucula nitidosa Winckworth, 1930		197	578	x	x	x	x	Ouest Afrique
Famille NUCULANIDAE H. et A.Adams, 1858								
Nuculana pella (Linné, 1767)		6	17	x	x	x		Ouest Afrique
Famille ARCIDAE Lamarck, 1809								
Arca noe Linné, 1758	1	1		x	x	x		Mauritanie-Sénégal
* *Anadara sp.*			1					
Famille GLYCYMERIDIDAE Dall, 1908								
Glycymeris violacescens (Lamarck, 1819)		35	25	x	x	x		
Famille MYTILIDAE Rafinesque, 1815								
Mytilus galloprovincialis Lamarck, 1819	3			x	x	x		
Mytilaster minimus (Poli, 1795)	2522	66	25	x	x	x		
***Musculus costulatus* (Risso, 1826)**	229	14	1	x	x	x	x	
***Musculus subpictus* (Cantraine, 1835)**	15	1496	1460	x	x	x	x	
* *Arcuatula senhousia* (Benson, 1842)	195	6	23	x				Océan Pacifique occidental
Modiolus barbatus (Linné, 1758)	10	3		x	x	x	x	
Gregariella petagnae (Scacchi, 1832)	267	13	18	x	x	x		Ouest Afrique
Famille PTERIIDAE Gray, 1847								
* *Pinctada radiata* (Leach, 1814)	2	1		(x)				Océan Indien et Mer Rouge

Tableau I. Suite.
Tabla I. Continuación.

	Algues sur rochers 0-1m	Fonds meubles 3-4m	Fonds meubles 10-15m	Méditerranée hors Alboran	Mer d'Alboran	Golfe ibero-Marocain	Atlantique Européen	Autres
Famille PECTINIDAE Rafinesque, 1815								
Mimachlamys varia (Linné, 1758)	6	18	9	x	x	x	x	
Flexopecten glaber (Linné, 1758)		23	14	x				
Flexopecten hyalinus (Poli, 1795)			5	x				
Aequipecten opercularis (Linné, 1758)		67	146	x	x	x	x	
Famille OSTREIDAE Rafinesque, 1815								
Ostrea stentina Payraudeau, 1826	18	2	1	x	x	x		Ouest Afrique
Famille ANOMIIDAE Rafinesque, 1815								
Anomia ephippium (Linné, 1758)	1	4	9	x	x	x	x	
Famille CARDITIDAE Fleming, 1828								
Cardita calyculata (Linné, 1758)	5			x	x	x		
Glans trapezia (Linné, 1767)		1		x				
Famille LUCINIDAE Fleming, 1828								
Lucinella divaricata (Linné, 1758)		31	16	x	x	x	x	
Loripes lacteus (Linné, 1758)		3	5	x	x	x	x	
Lucinidae			10					
Anodontia fragilis (Philippi, 1836)		13	20	x	x	x		
Famille THYASIRIDAE Dall, 1900								
Thyasira flexuosa (Montagu, 1803)			1	x	x	x	x	
Famille LEPTONIDAE Gray, 1847								
Hemilepton nitidum (Turton, 1822)		12	19	x	x	x	x	
Famille MONTACUTIDAE Clark, 1855								
Kurtiella bidentata (Montagu, 1803)		8	12	x	x	x	x	
Scacchia oblonga (Philippi, 1836)		1		x	x	x		Ouest Afrique
Famille CARDIIDAE Lamarck, 1809								
* *Fulvia fragilis* (Forsskål in Niebuhr, 1775)		6	4	(x)				Mer Rouge
Acanthocardia tuberculata (Linné, 1758)		7		x	x	x	x	
Acanthocardia paucicostata (Sowerby, 1841)		105	82	x	x	x	x	
***Parvicardium scriptum* (B.D.D., 1892)**	45			x	x	x		
***Parvicardium exiguum* (Gmelin, 1791)**	1	329	97	x	x	x	x	
Famille CHAMIDAE Lamarck, 1809								
Chama gryphoides Linné, 1758	1			x	x	x		
Famille MACTRIDAE Lamarck, 1809								
Mactra stultorum (Linné, 1758)		946	10	x	x	x	x	
Spisula subtruncata (da Costa, 1778)		9	3	x	x	x	x	
Eastonia rugosa (Helbling, 1799)	2			(x)	x	x		Ouest Afrique
Famille TELLINIDAE Blainville, 1814								
Tellina distorta Poli, 1791		97	172	x	x	x		Ouest Afrique
Tellina fabula Gmelin, 1791		2	3	x	x	x	x	
Tellina nitida Poli, 1791		319	339	x	x			
Tellina pulchella Lamarck, 1818		8	14	x	x			

Tableau I. Suite.
Tabla I. Continuación.

	Algues sur rochers 0-1m	Fonds meubles 3-4m	Fonds meubles 10-15m	Méditerranée hors Alboran	Mer d'Alboran	Golfe ibero-Marocain	Atlantique Européen	Autres
Tellina planata Linné, 1758		1		x	x	x		
Tellina tenuis da Costa, 1778		1		x	x	x	x	
Gastrana fragilis (Linné, 1758)	2			x	x	x	x	
Macoma cumana (Costa, 1829)		21	33	x	x			Ouest Afrique
Famille SEMELIDAE Stoliczka, 1870								
***Abra alba* (Wood W., 1802)**	2	84	295	x	x	x	x	
***Abra nitida* (Müller O.F., 1776)**		24	659	x	x	x	x	
Famille DONACIDAE Fleming, 1828								
Donax venustus Poli, 1795		462	31	x	x	x		
Donax semistriatus Poli, 1795		26		x	x			
Famille SOLECURTIDAE d'Orbigny, 1846								
Azorinus chamasolen (da Costa, 1778)		2	6	x	x	x	x	
Famille PHARIDAE H. et A. Adams, 1858								
Pharus legumen (Linné, 1758)		101	120	x	x	x	x	
Phaxas pellucidus (Pennant 1777)	10	13	133	x	x	x	x	
Famille SOLENIDAE Lamarck, 1809								
Solen marginatus Pulteney, 1799		3	8	x	x	x	x	
Famille VENERIDAE Rafinesque, 1815								
Chamelea gallina (Linné, 1758)	1	296	25	x	x	x		
Tapes decussatus (Linné, 1758)	76			x	x	x	x	
Venerupis aurea (Gmelin, 1791)	572	62	16	x	x	x	x	
Venerupis geographica (Gmelin, 1791)	52			x	x	x		
Pitar rudis (Poli, 1795)		32	53	x	x	x		Ouest Afrique
Dosinia lupinus (Linné, 1758)		1455	711	x	x	x	x	
Petricola lithophaga (Retzius, 1788)	468			x	x	x		
Irus irus (Linné, 1758)	69			x	x	x	x	
Famille CORBULIDAE Lamarck, 1818								
Lentidium mediterraneum (Costa, 1829)		1						
Corbula gibba (Olivi, 1792)		1007	2353	x	x	x	x	
Famille HIATELLIDAE Gray, 1824								
Hiatella arctica (Linné, 1767)		3	2	x	x	x	x	
Famille PANDORIDAE Rafinesque, 1815								
Pandora inaequivalvis (Linné, 1758)		58	70	x	x	x	x	
Classe des *SCAPHOPODES*								
Famille FUSTIARIIDAE Steiner, 1991								
Fustiaria rubescens (Deshayes, 1825)		108	217	x	x			
Famille DENTALIIDAE Gray, 1847								
Antalis vulgaris (da Costa, 1778)		73	102	x	x	x	x	
Antalis novemcostata (Lamarck, 1818)			1					
Total	16105	11780	12386					

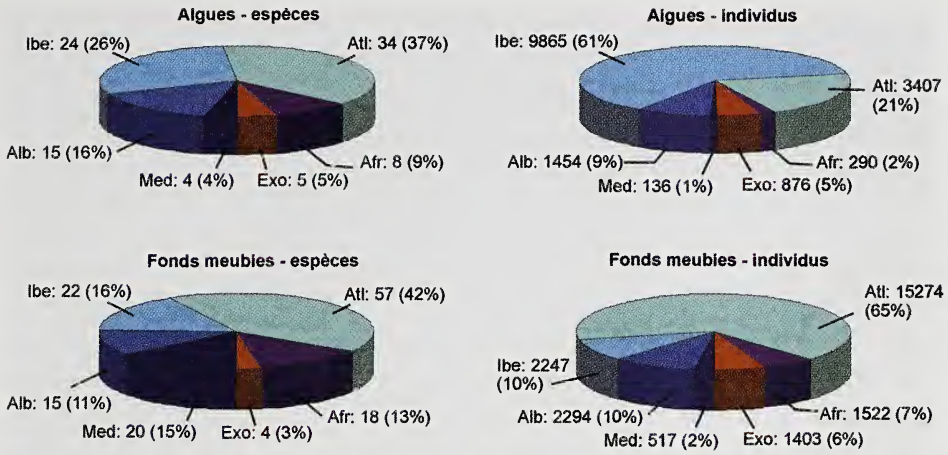

Figure 3. Affinité biogéographique des espèces de Mollusques recueillies à La Goulette, en fonction du nombre d'espèces (à gauche) et du nombre d'individus (à droite). Med: Espèces strictement méditerranéennes ne pénétrant pas en Mer d'Alboran ni dans l'Atlantique. Alb: Espèces strictement méditerranéennes pénétrant en Mer d'Alboran mais pas dans l'Atlantique; Ibe: Espèces lusitaniennes, présentes en Méditerranée et dans le Golfe Ibéro-Marocain; Atl: Espèces présentes en Méditerranée et dans l'Atlantique européen au moins jusqu'au Golfe de Gascogne; Afr: Espèces présentes en Méditerranée et en Afrique occidentale, au moins jusqu'au Sénégal; Exo: Espèces non-indigènes en Méditerranée.

Figura 3. Afinidad biogeográfica de las especies de moluscos recogidas en La Goulette, en función del número de especies (izquierda) y del número de individuos (derecha). Med: Especies estrictamente mediterráneas que no penetran en el mar de Alborán ni en el Atlántico. Alb: Especies estrictamente mediterráneas que entran en el mar de Alborán, pero no en el Atlántico, Ibe: Especies lusitanas, presentes en el Mediterráneo y en el Golfo Ibero-Marroquí, Atl: Especies presentes en el Mediterráneo y en el Atlántico europeo al menos hasta el Golfo de Vizcaya; Afr: Especies presentes en el Mediterráneo y el África occidental, al menos hasta Senegal, Exo: Especies no-autóctonas en el Mediterráneo.

taux d'endémisme de 20% avancé par COLL ET AL. (2010) pour l'ensemble des espèces vivantes de Méditerranée. La proportion de cet ensemble se réduit à seulement 12% si l'on considère le nombre des individus.

Les sept espèces non-indigènes, toutes origines confondues, représentent 3,6% des espèces mais 5,6% des individus. Il apparaît donc, au vu de ces chiffres, que les espèces à large répartition et les espèces non-indigènes sont représentées par des effectifs plus fournis que les endémiques méditerranéennes.

Du point de vue du nombre d'espèces, ces chiffres varient peu si l'on considère séparément les communautés des fonds meubles et la communauté des algues photophiles. La proportion d'espèces strictement méditerranéennes (sans la mer d'Alboran) est cependant très réduite dans la communauté des algues, et la proportion d'espèces ayant une distribution ouest africaine en plus de la Méditerranée est un peu plus importante sur les fonds meubles. En revanche, du point de vue du nombre d'individus, il y a une prépondérance marquée (63%) des espèces « lusitaniennes » dans la faune des algues tandis que sur les fonds meubles, cette prépondérance (65%) appartient aux espèces s'étendant assez loin vers le nord. La proportion, en nombre d'individus, d'espèces strictement méditerranéennes (sans la mer d'Alboran) est insignifiante dans la communauté des algues.

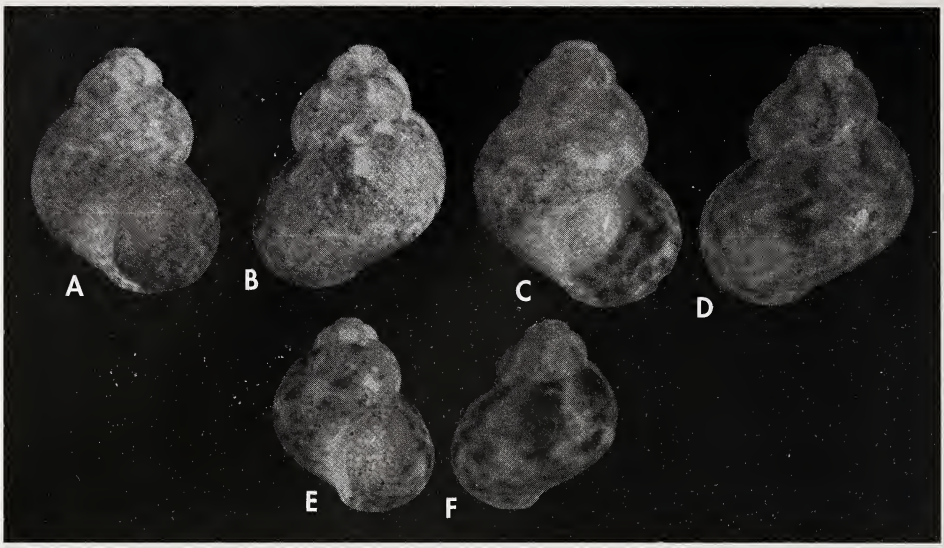

Figure 4. A-F. *Tricolia miniata* (Monterosato, 1884), exemplaires de La Goulette (algues sur rochers, 30.06.2008), taille réelle 2,5, 2,4 et 1,8 mm.
Figura 4. A-F. Tricolia miniata *(Monterosato, 1884), ejemplares de La Goulette (algas sobre rocas, 30.06.2008), tamaño real 2,5, 2,4 y 1,8 mm.*

NOTES TAXONOMIQUES SUR CERTAINES ESPÈCES

Tricolia miniata (Monterosato, 1884) (Fig. 4)

Référence originale: *Tricoliella punctata* var. *miniata* Monterosato, 1884: *Nomenclatura generica e specifica di alcune conchiglie mediterranee*, p. 50 [Localité type: Tanger].
Synonymie en usage: *Tricolia jolyi* (Monterosato, 1889)
Référence à des descriptions publiées: Gofas, 1982: p. 197-200; Gofas, Moreno et Salas, 2011, p. 132.
Citation en Tunisie: Antit et al., 2009.

Cette petite espèce (2 à 2,5mm de hauteur seulement) se caractérise par une coquille globuleuse, avec un peu plus de 3 tours de spires très convexes, et la suture très profonde. Le dernier tour est bien arrondi, contrairement à *T. pullus* chez laquelle il tend à s'aplatir en dessous de la suture; l'avant dernier tour est également plus globuleux. L'ouverture est arrondie et le bord columellaire est en principe un peu décollé du dernier tour, pouvant même laisser apparaître une fente ombilicale. *Tricolia tenuis* (Michaud, 1829) est de forme générale beaucoup plus élevée, avec les tours beaucoup moins convexes et l'apex beaucoup moins aplati. *Tricolia pullus* (Linné, 1758) est plus robuste, avec la spire plus pointue et plus conique.Ces deux autres espèces atteignent une taille plus grande, de 4 à 5 mm. Contrairement à ces deux autres espèces, *Tricolia miniata* vit parmi les algues tapissant le fond rocheux, en général à des niveaux très superficiels, à moins d'un mètre de fond.

La distribution de cette espèce n'est pas bien connue, peut-être parce qu'elle a été confondue avec *T. pullus*, peut-être parce qu'elle passe facilement inaperçue, mais aussi peut-être parce que cette distribution est changeante. Elle est commune sur les côtes marocaines et aux abords du Détroit de Gibraltar, également sur la côte espagnole (Gofas et al., 2011).

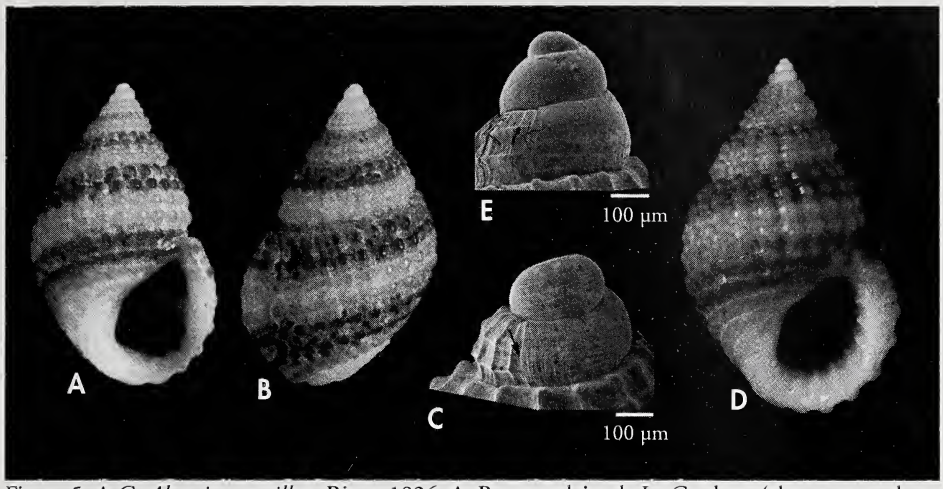

Figure 5. A-C. *Alvania mamillata* Risso, 1826. A, B: exemplaire de La Goulette (algues sur rochers, 22.06.2008), taille réelle 4,9mm; C: même provenance, protoconque en microscopie électronique à balayage; la flèche indique la limite protoconque-téléoconque. D, E. *Alvania cimex* (Linné, 1758). D: exemplaire de Benalmadena (Málaga, Espagne) pour comparaison, taille réelle 5,15mm; E: protoconque en microscopie électronique à balayage, exemplaire de Denia (Valencia, Espagne) (D, E reproduit de Gofas et Oliver, in GOFAS, MORENO ET SALAS, 2011, p. 178; D, photographie de J.D. Oliver).

Figura 5. A-C. Alvania mamillata *Risso, 1826. A, B: ejemplar de La Goulette (algas sobre rocas, 22.06.2008), tamaño real 4,9 mm; C: misma localidad, protoconcha vista al microscopio electrónico de barrido, la flecha indica el límite protoconcha-teleoconcha. D, E.* Alvania cimex *(Linné, 1758). D: ejemplar de Benalmádena (Málaga, España) para comparación, tamaño real 5,15 mm; E: protoconcha vista al microscopio electrónico de barrido, ejemplar de Denia (Valencia, España) (D, E reproducido de Gofas y Oliver, en GOFAS, MORENO Y SALAS, 2011, p 178; D, fotografía de J.D. Oliver).*

Alvania mamillata Risso, 1826 (Fig. 5)

Référence originale: *Alvania mamillata* Risso, 1826: *Histoire naturelle des principales productions de l'Europe Méridionale*, vol. 4, p. 145, pl. 9 fig. 128 [Localité type: région de Nice, côte méditerranéenne de France]

Référence à des descriptions publiées: Verduin, 1986, p. 25-32; Scaperrota et al. 2011, p. 66.

Citation en Tunisie: Pallary, 1914, sous le nom de *Rissoa cimex* var. *depauperata* Monterosato, 1877; Fekih et Gougerot, 1974: p. 188 (sous le nom de *Alvania cimex* «et variétés»); cité de Sfax par Verduin, 1986; cité de Tabarka par Campani, 2008.

VERDUIN (1986) distingue par le nom de *A. mamillata* Risso, 1826, des formes semblables à *Alvania cimex* (Linné, 1758) (Fig. 5 D,E) mais qui n'ont que 1,5 tours de protoconque au lieu de 2,5 chez *Alvania cimex* proprement dite (SCAPERROTA ET AL., 2011: p. 57). C'est cette forme qui est représentée dans le matériel de La Goulette. D'autre part, il y a des formes possédant une protoconque également paucispirale, mais avec un angle très marqué sur le premier tour, qui constituent une espèce clairement distincte, *A. aartseni* Verduin 1986, dont la distribution est limitée aux côtes algériennes et qui n'est pas représentée dans notre matériel. La distribution de cette espèce est méditerranéenne, mal connue en raison de la confusion habituelle avec *A. cimex*.

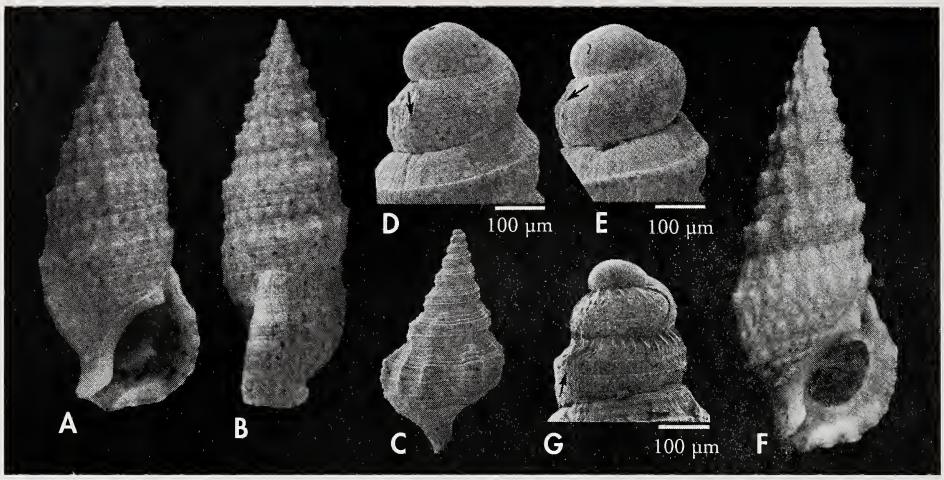

Figure 6. A-E. *Cerithium repandum* Monterosato, 1878. A, B: exemplaire de La Goulette (épifaune sur *Cymodocea nodosa*, 19.09.2008), taille réelle 28 mm; C: exemplaire juvénile de La Goulette (algues sur rochers, 18.02.2009), au microscope électronique à balayage; D: protoconque du même juvénile, la flèche indique la limite protoconque-téléoconque; E: protoconque d'un autre exemplaire juvénile, même provenance. F. *Cerithium vulgatum* Bruguière, 1792, exemplaire de Almeria, Espagne, taille réelle 45 mm. G. *Cerithium vulgatum*, protoconque d'un juvénile de Marina del Este, Granada, Espagne, à la même échelle que D, E; la flèche indique la limite protoconque-téléoconque. (F, G reproduit de Moreno in Gofas *et al.*, 2011, p. 137; photographie de D. Moreno).

Figura 6. A-E. Cerithium repandum *Monterosato, 1878. A, B: ejemplar de La Goulette (epifauna de* Cymodocea nodosa, *09/19/2008), tamaño real 28 mm; C: ejemplar juvenil de La Goulette (algas sobre rocas, 18.02.2009), visto al microscopio electrónico de barrido; D: protoconcha del mismo ejemplar juvenil, la flecha indica el límite protoconcha-teleoconcha; E: protoconcha de otro ejemplar juvenil, misma procedencia. F.* Cerithium vulgatum *Bruguière, 1792, ejemplar de Almería, España, tamaño real 45 mm. G.* Cerithium vulgatum, *protoconcha de un ejemplar juvenil de Marina del Este, Granada, España, en la misma escala que D, E; la flecha indica el límite protoconcha-teleoconcha (F, G reproducido de Moreno en* Gofas et al., *2011, p. 137; fotografía de D. Moreno).*

Cerithium repandum Monterosato, 1878 (Fig. 6)

Référence originale: *Cerithium vulgatum* var. *repanda* Monterosato, 1878, *Giornale di Scienze Naturali ed Economiche di Palermo*, p. 97 [localité type: «côtes de Syrie», ce qui dans le contexte de cette publication peut se rapporter à n'importe quelle localité d'Afrique du Nord ou du moyen Orient, avec l'importation des éponges.]

Référence à des descriptions publiées: Boisselier-Dubayle et Gofas, 1999; Cecalupo, Buzzurro et Mariani, 2008, p. 75-77-

Citation en Tunisie: Pallary, 1914, p. 17, sous le nom de *C. vulgatum* Bruguière, 1792; Cecalupo, Buzzurro et Mariani, 2008.

Les travaux de génétique de Boisselier-Dubayle et Gofas (1999) montrent qu'il existe un complexe d'espèces ressemblant à *Cerithium vulgatum* Bruguière, 1792 et qui diffèrent essentiellement par le développement larvaire. Chez *Cerithium vulgatum* (Fig. 6 F, G), il y a un développement larvaire planctonique avec une protoconque multispirale, formée de près de trois tours et ornée de côtes axiales sur la zone subsuturale et de rangées spirales de granules sur le reste de la surface. Il est clair que la population de La Goulette présente

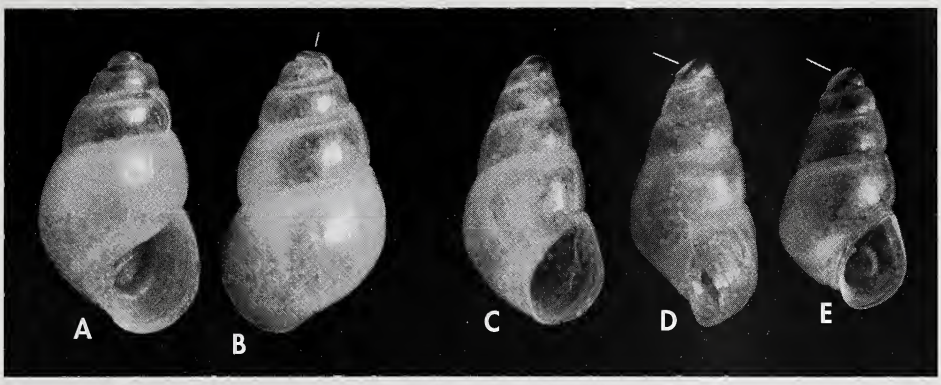

Figure 7. A-C. *Odostomia lukisii* Jeffreys, 1859, exemplaire de La Goulette (algues sur rochers, 22.06.2008), taille réelle 1,8 mm. D, E. *Odostomia kromi* van Aartsen, Menkhorst et Gittenberger, 1984, exemplaires de La Goulette (algues sur rochers, 27.05.2009), taille réelle 1,6 et 1,3 mm. Les traits blancs représentent l'axe d'enroulement de la protoconque.
Figura 7. A-C. Odostomia lukisii *Jeffreys, 1859, ejemplar de La Goulette (algas sobre rocas, 22.06.2008), tamaño real 1,8 mm. D, E.* Odostomia kromi *van Aartsen, Menkhorst y Gittenberger, 1984, ejemplares de La Goulette (algas sobre rocas, 27.05.2009), tamaño real 1,6 y 1,3 mm. Las líneas blancas representan el eje de enrollamiento de la protoconcha.*

une protoconque paucispirale et ne correspond donc pas au véritable *C. vulgatum* qui doit être multispiral. Cecalupo, Buzzurro et Mariani (2008) représentent (leur figure 7 pl. 24) une protoconque identique à celle observée sur les spécimens de La Goulette et retiennent pour ces formes le nom de *Cerithium repandum* Monterosato, 1878. Il n'est pas exclu que le véritable *Cerithium vulgatum* existe en Tunisie mais cela reste à confirmer avec les coquilles larvaires; la protoconque de *C. vulgatum* représentée (leur figure 14 pl. 23) par Cecalupo, Buzzurro et Mariani (2008), dont la provenance n'est pas indiquée, provient en fait des environs de Marseille, France (photographie de S. Gofas). L'espèce trouvée à La Goulette vit sur les fonds rocheux et vaseux des étages médiolittoral et infralittoral. Sa distribution est mal connue en raison de la confusion avec *Cerithium vulgatum*, mais elle se trouve en divers points de la Méditerranée.

Odostomia lukisii Jeffreys, 1859 (Fig. 7 A, B)

Référence originale: *Odostomia lukisii* Jeffreys, 1859: *Annals and Magazine of Natural History* (3)3, p. 112-113, pl. 3 fig. 19 a-b [Localité type: Grande Bretagne].

Référence à des descriptions publiées: Fretter et Graham, 1986, p. 604-606; Scaperrota et al., 2011, p. 119; Peñas et Rolán, in Gofas, Moreno et Salas, 2011: p. 383.

Cette espèce est signalée ici pour la première fois dans la malacofaune de Tunisie. Contrairement à d'autres espèces d'*Odostomia* chez lesquelles l'axe d'enroulement de la protoconque forme un angle de 90 à 140° avec l'axe de la téléoconque, chez *O. lukisii* cet axe forme un angle de pratiquement 180° (protoconque dite de type C). Ce caractère, avec l'aspect solide et luisant de cette petite espèce, la rend assez facilement reconnaissable. Elle se trouve sur les fonds rocheux de l'infralittoral avec couverture d'algues photophiles. Sa diistribution s'étend dans toute la Méditerranée et dans Atlantique, depuis les Îles Britanniques jusqu'à la Mauritanie et en Angola; aussi aux îles Canaries et à Madère.

Odostomia kromi van Aartsen, Menkhorst et Gittenberger, 1984 (Fig. 7 C-E)

Référence originale: *Odostomia kromi* van Aartsen, Menkhorst et Gittenberger, 1984: *Basteria*, supplément 2, p. 52 [Localité type: Getares, détroit de Gibraltar, Espagne].
Référence à des descriptions publiées: van Aartsen, Menkhorst et Gittenberger, 1984.
Citation en Tunisie: van Aartsen, Menkhorst et Gittenberger, 1984, p. 52 (Sidi Daoud).

Cette espèce peut facilement être confondue avec *Odostomia turrita* Hanley, 1844, qui est de dimensions et d'aspect très similaires et ne diffère que par la protoconque. Chez *O. turrita*, la protoconque, dite de type A, possède un axe d'enroulement à peu près perpendiculaire à la spire de l'adulte et son premier tour est très proéminent, comme appuyé sur le premier tour de téléoconque et même un peu saillant (Scaperrota et al., 2011, p. 123); chez *O. kromi* au contraire la protoconque (dite de type B) forme un angle de 135° avec l'axe d'enroulement de l'adulte, donc pointe nettement vers le bas; elle est globuleuse et le premier tour de protoconque est peu saillant et plus ou moins couvert par le premier tour de téléoconque. *Odostomia plicata* (Montagu, 1803) lui ressemble également mais sa forme générale est plus cylindrique, ses tours sont à peine convexes, le dernier bien arrondi à la périphérie et la protoconque, quoique de forme semblable à celle de *O. kromi*, possède un axe d'enroulement bien perpendiculaire à celui de la téléoconque, non infléchi vers le bas. Ces différences sont subtiles et il n'est donc pas étonnant qu'il ait fallu attendre 1984 pour que cette espèce soit distinguée; elle est citée de Tunisie dans la description originale. Cette espèce habite les fonds rocheux de l'infralittoral avec couverture d'algues photophiles, et n'est connue que de la Méditerranée, jusqu'au Détroit de Gibraltar.

Chrysallida sigmoidea (Monterosato, 1880) (Fig. 8 A-C)

Référence originale: *Odostomia sigmoidea* Monterosato, 1880: *Bullettino della Società Malacologica Italiana*, 7, p. 71 [Localité type: Alger et Tanger].
Référence à des descriptions publiées: Peñas, Templado et Martínez, 1996, p. 46-48; Peñas et Rolán, in Gofas, Moreno et Salas, 2011, p. 374.

Cette espèce est ici signalée pour la première fois sur le littoral de Tunisie, qui constitue la limite Est de sa répartition connue. Elle se caractérise par une coquille de petite taille (taille moyenne: 4,2 x 1,0 mm), entièrement blanche, subcylindrique, très allongée, mince et hyaline. La protoconque est du type C, formée par environ un tour lisse, avec un profil caractéristique large et aplati au sommet. La téléoconque possède au moins 6 tours convexes, avec la convexité maximale située dans le tiers inférieur, et une suture profonde. La sculpture axiale est composée d'environ 20 côtes très flexueuses, opisthoclines, plus large que leurs intervalles, qui disparaissent atténuées vers la base du dernier tour; la sculpture spirale est composée de stries nombreuses, plus apparentes dans le bas des tours et vers la base. L'ouverture est ovalaire, avec une columelle mince, sans aucun pli columellaire, ni ombilic.

Plusieurs caractères bien tranchés permettent de distinguer cette espèce de la plupart des *Chrysallida* méditerranéennes. La présence de cordons spiraux sur l'ensemble des tours, de suture à suture, n'est pas habituelle et ne se trouve chez aucune autre espèce à spire étroite et allongée. En fait, l'espèce la plus ressemblante à sa coquille est *Graphis albida*, qui appartient à une autre famille (Cimidae), elle possède une protoconque dont l'enroulement est en continuité avec celui de la téléoconque, et un profil encore plus étroit et délicat. Fekih et Gougerot (1974) annonçaient la description prochaine d'une espèce nouvelle « *Chrysallida tunetana* », qui finalement n'a jamais été publiée. Par élimination des autres espèces

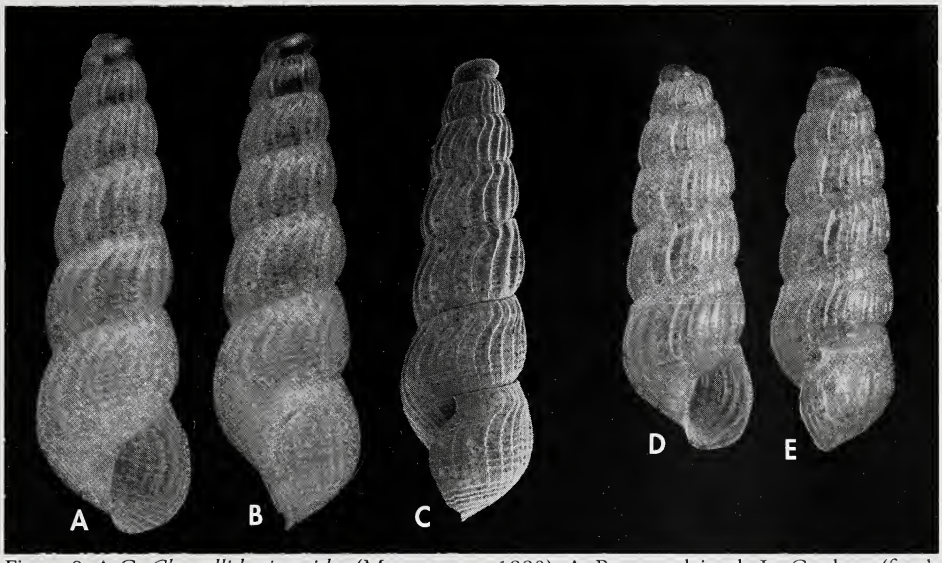

Figure 8. A-C. *Chrysallida sigmoidea* (Monterosato, 1880). A, B: exemplaire de La Goulette (fonds meubles 10-15 m, 19.01.2010), taille réelle 2,7 mm; C: exemplaire au microscope électronique à balayage, taille réelle 2,5 mm. D, E. *Chrysallida indistincta* (Montagu, 1808), exemplaire de La Goulette (fonds meubles 10-15 m, 20.10.2009), taille réelle 2,1 mm.
Figura 8. A-C. Chrysallida sigmoidea *(Monterosato, 1880). A, B: ejemplar de La Goulette (fondos de 10-15 m, 19.01.2010), tamaño real 2,7 mm; C: ejemplar visto al microscopio electrónico de barrido, tamaño real 2,5 mm. D, E.* Chrysallida indistincta *(Montagu, 1808), ejemplar de La Goulette (fondos de 10-15 m, 20.10.2009), tamaño real 2,1 mm.*

citées par ces auteurs, on peut supposer que c'est la présente espèce, alors peu connue dans la littérature, qu'ils avaient en vue. Cette espèce vit sur les fonds meubles de l'étage infralittoral. Elle est connue dans l'Atlantique depuis le Golfe de Gascogne jusqu'à l'Angola et aux Iles du Cap Vert. En Méditerranée, elle pénètre dans la mer d'Alboran et le long de la côte nord-africaine à jusqu'à Tunis.

Chrysallida indistincta (Montagu, 1808) (Fig. 8 D, E)

Référence originale: *Turbo indistinctus* Montagu, 1808: *Testacea Britannica*, supplément, p. 129 [Localité type: non précisée (Iles Britanniques)].

Référence à des descriptions publiées: Fretter et Graham, 1986, p. 564-566; Peñas et Rolán, in Gofas, Moreno et Salas, 2011, p. 371.

Citation en Tunisie: Pallary, 1974, p. 20; Fekih et Gougerot, 1974, p. 174, sous le nom de *Parthenina indistincta*.

Cette espèce relativement difficile à identifier est caractérisée par une coquille de très petite taille (taille moyenne: 2,1 x 0,7 mm), subcylindrique, très allongée, mince et hyaline. La protoconque du type C, formée par environ un tour lisse, avec un profil caractéristique large et aplati au sommet. La téléoconque est formée par environ 5 tours convexes, avec la convexité maximale située dans le tiers inférieur. La sculpture axiale composée d'environ 20 côtes flexueuses, opisthoclines, à peu près de même grosseur que leurs intervalles, et qui disparaissent sur le dernier tour, en dessous d'une ligne qui prolonge la suture. La sculpture

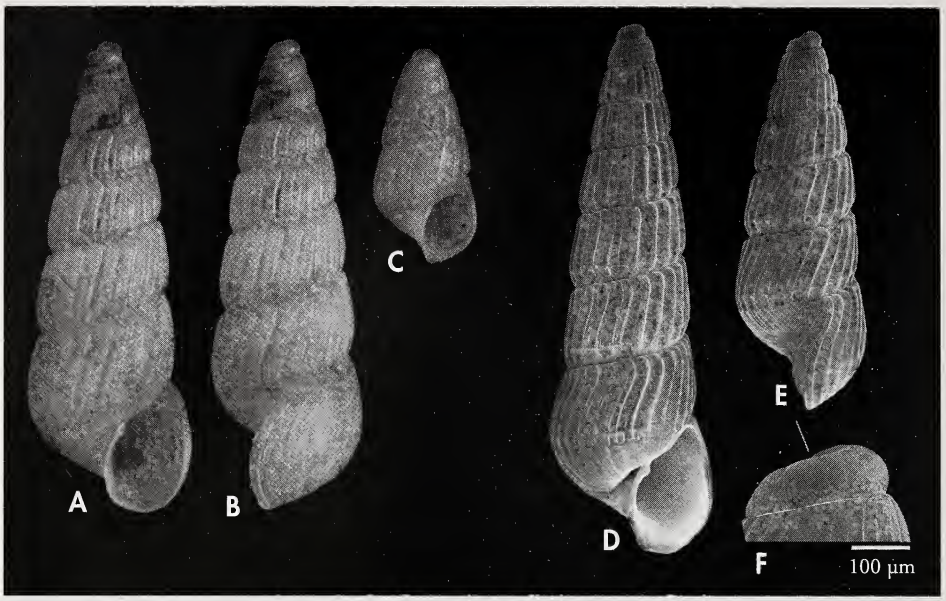

Figure 9. *Chrysallida terebellum* (Philippi, 1844). A, B: exemplaire de La Goulette (fonds meubles 10-15 m, 19.01.2010), taille réelle 3,0 mm; C: exemplaire juvénile 1,4 mm, même provenance; D, E: exemplaires au microscope électronique à balayage, taille réelle 3,2 et 2,3 mm; F: détail de la protoconque; trait d'échelle 100 µm, même exemplaire que E; la flèche indique la limite protoconque-téléoconque, le trait pointillé indique l'axe d'enroulement de la protoconque.
Figura 9. Chrysallida terebellum *(Philippi, 1844). A, B: ejemplar de La Goulette (fondos de 10-15 m, 19.01.2010), tamaño real 3,0 mm; C: ejemplar juvenil de 1,4 mm, misma localidad; D, E: ejemplares vistos al microscopio electrónico de barrido, tamaño real 3,2 y 2,3 mm. F: detalle de la protoconcha, escala 100 µm, mismo ejemplar que E. La flecha indica el límite protoconcha-teleoconcha, la línea blanca indica el eje de enrollamiento de la protoconcha.*

spirale est formée par deux ou trois cordons situés quelque peu au dessus de la suture, et quelquefois une très faible sculpture visible dans les intervalles des côtes sur la partie moyenne des tours. L'ouverture est ovalaire, avec une columelle mince, sans aucun pli columellaire ce qui permet de la distinguer sans ambiguïté des juvéniles de *C. terebellum*, en compagnie desquels elle se trouve sur les mêmes fonds meubles de l'infralittoral. Cette espèce est connue en Méditerranée et dans l'Atlantique, de la Scandinavie au Maroc ainsi qu'aux Canaries et à Madère.

Chrysallida terebellum (Philippi, 1844) (Fig. 9)

Référence originale: *Chemnitzia terebellum* Philippi, 1844: *Enumeratio Molluscorum Siciliae*, vol. 2, p. 138, pl. 24 fig. 12 [Localité type: Palerme, fossile pléistocène].
Référence à des descriptions publiées: Fretter et Graham, 1986: p. 564-566; Gofas, Moreno et Salas, 2011, p. 374.
Citation en Tunisie: Fekih et Gougerot, 1974: p. 174, sous le nom de *Parthenina terebellum*.

Cette espèce ressemble beaucoup, par sa forme très allongée, à *Chrysallida indistincta* (Montagu, 1808) mais cette dernière ne présente pas de pli columellaire (donc présente une ouverture semblable à celle de *C. juliae*); la forme générale de *C. indistincta* est moins conique et presque cylindrique, avec un apex plus large; aussi, chez

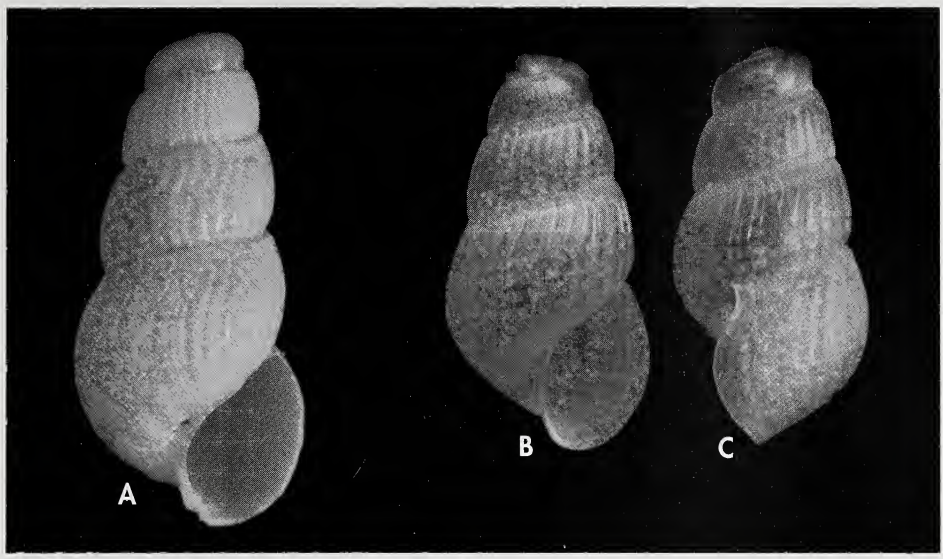

Figure 10. *Chrysallida juliae* (de Folin, 1872). A: exemplaire de La Goulette, coquille vide (fonds meubles 10-15 m, 24.11.2009), taille réelle 1,7 mm; B, C: exemplaire récolté vivant de la même localité (fonds meubles 10-15 m, 31.03.2010), taille réelle 1,4 mm.
Figura 10. Chrysallida juliae *(de Folin, 1872). A: ejemplar de La Goulette, concha vacía (fondos blandos 10-15 m, 24.11.2009), tamaño real 1,7 mm; B, C: ejemplar recogido vivo de la misma localidad (fondos de 10-15 m, 31.03.2010), tamaño real 1,4 mm.*

C. indistincta il y a au moins deux cordons situés un peu au dessus de la suture alors que *C. terebellum* présente un seul cordon au dessus de la suture et un autre confondu avec elle et la prolongeant sur le dernier tour. Ces différences sont subtiles et font que la détermination nécessite un examen très attentif. *Chrysallida terebellum* est une espèce extrêmement typique des fonds meubles de l'étage infralittoral, connue en Méditerranée et dans l'Atlantique depuis la Manche jusqu'au détroit de Gibraltar.

Chrysallida juliae (de Folin, 1872) (Fig. 10)

Référence originale: *Truncatella juliae* De Folin, 1872: *Les Fonds de la Mer*, vol. 2, p. 48, pl. 2 fig. 4 [Localité type: Hendaye, côte atlantique de France].
Synonymie en usage: *Chrysallida nanodea* (Monterosato, 1878)
Référence à des descriptions publiées: Micali, Nofroni et van Aartsen, 1993; Scaperrota et al., 2011, p. 102; Gofas, Moreno et Salas, 2011: p. 370.
Citation en Tunisie: Fekih et Gougerot, 1974, sous le nom de *Parthenina nanodea*

Cette espèce rarement citée est facilement reconnaissable par un ensemble de caractères comprenant l'absence de pli columellaire, le type de sculpture relativement fin et la forme assez trapue, tronquée au sommet. *Chrysallida indistincta* (Montagu, 1808) possède une sculpture similaire, mais une forme beaucoup plus étroite et allongée et des cordons spiraux beaucoupmoins nombreux. Fekih et Gougerot citent de la Baie de Tunis *Chrysallida nanodea* (Monterosato, 1878), que Micali et al. (1993) ont montré être un synonyme plus récent de *C. juliae*. Il s'agit d'une espèce typique des fonds meubles de l'étage infralittoral, connue en Méditerranée et dans l'Atlantique depuis le Golfe de Gascogne jusqu'au Sénégal.

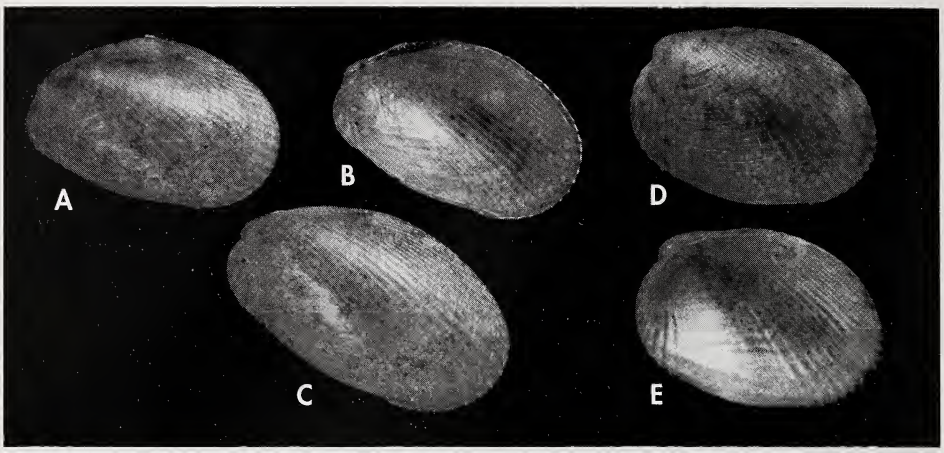

Figure 11. A-C. *Musculus costulatus* (Risso, 1826), exemplaires de Salakta (Golfe de Hammamet). A: valve gauche en vue externe, taille réelle 3,2 mm; B: vue interne de la valve droite du même spécimen; C: valve gauche en vue externe, taille réelle 3,7 mm. D, E. *Musculus subpictus* (Cantraine, 1835), exemplaire de La Goulette, (fonds meubles 10-15 m, 29.06.2009), taille réelle 2,2 mm. D: valve gauche en vue externe; E: vue interne de la valve droite du même spécimen.
Figura 11. A-C. Musculus costulatus *(Risso, 1826), ejemplares de Salakta (Golfo de Hammamet). A: valva izquierda en vista exterior, tamaño real 3,2 mm, B: vista interior de la valva derecha del mismo ejemplar; C: valva izquierda en vista externa, tamaño real 3,7 mm. D, E.* Musculus subpictus *(Cantraine, 1835), ejemplaress de La Goulette (fondos blandos 10-15 m, 29.06.2009), tamaño real 2,2 mm. D: valva izquierda en vista externa; E: vista interna de la valva derecha del mismo ejemplar.*

Musculus costulatus (Risso, 1826) (Fig. 11 A-C)

Référence originale: *Modiolus costulatus* Risso, 1826: *Histoire naturelle des principales productions de l'Europe Méridionale*, vol. 4, p. 324, pl. 11, fig. 165 [Localité type: région de Nice, côte méditerranéenne de France].
Référence à des descriptions publiées: Tebble, 1966, p. 47; Gofas, Moreno et Salas, 2011, p. 569.
Citation en Tunisie: Delamarre, Dhainault, Gratecap et Jaux, 2008; Antit et al. 2011.

Cette espèce ressemble le plus à *Musculus subpictus* (Cantraine, 1835) mais cette dernière a une forme beaucoup plus courte, plus renflée et non rétrécie vers l'avant; les deux espèces se distinguent très nettement lorsqu'elles coexistent. *Arcuatula senhousia* (Benson in Cantor, 1842), une espèce d'origine Indo-Pacifique qui se trouve aussi dans le matériel de La Goulette, possède aussi une forme générale un peu similaire mais plus grande (jusqu'à 20 mm) et son contour est plus trapézoïdal du coté postérieur, les côtes sont beaucoup plus aplaties et émoussées, surtout chez les juvéniles qui se distinguent ainsi très clairement des juvéniles de *M. costulatus* où les côtes sont clairement imprimées dès le début de la croissance post-larvaire. Son habitat se situe parmi les algues photophiles dans les milieux rocheux de l'infralittoral. Elle est connue en Méditerranée et dans l'Atlantique, depuis les Iles Britanniques jusqu'à la Mauritanie.

Musculus subpictus (Cantraine, 1835) (Fig. 11 D, E)

Référence originale: *Modiolus subpictus* Cantraine, 1835: *Bulletins de l'Académie Royale des Sciences et Belles-Lettres de Bruxelles*, 2 (11), p. 397 [Localité type: Golfe de Venise, Italie]

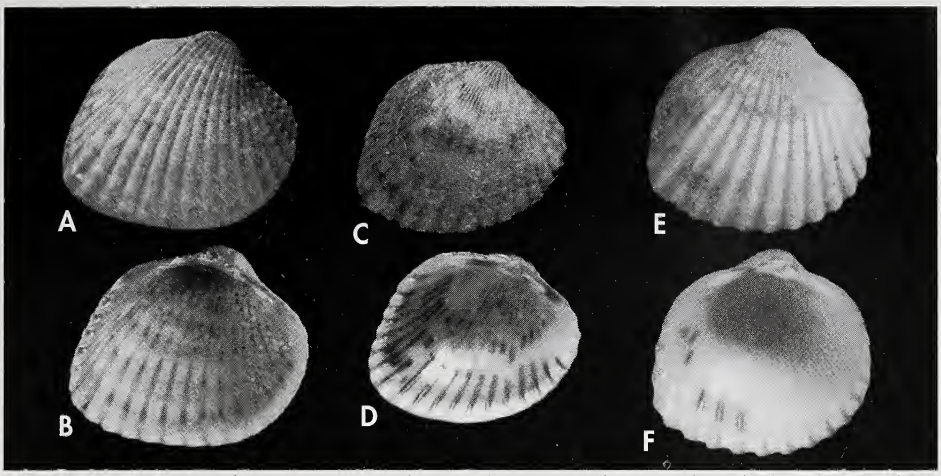

Figure 12. A, B. *Parvicardium exiguum* (Gmelin, 1791), spécimen de La Goulette (herbier de *Cymodocea*, 28.05.2009), extérieur de la valve droite et intérieur de la valve gauche; taille réelle 9,3 mm. C, D. *Parvicardium exiguum*, spécimen juvénile, même localité (14.09.2008), taille réelle 3,6 mm. E, F. *Parvicardium scriptum* (Bucquoy, Dautzenberg et Dollfus, 1892), spécimen de La Goulette (herbier de *Cymodocea*, 30.03.2009), extérieur de la valve droite et intérieur de la valve gauche; taille réelle 4,3 mm. *Figura 12. A, B.* Parvicardium exiguum *(Gmelin, 1791), ejemplar de La Goulette (pradera de* Cymodocea, *05/28/2009), exterior de la valva derecha e interior de la valva izquierda, tamaño real 9,3 mm. C, D.* Parvicardium exiguum, *ejemplar juvenil, misma localidad (14/09/2008), tamaño real 3,6 mm. E, F.* Parvicardium scriptum *(Bucquoy, Dautzenberg y Dollfus, 1892), ejemplar de La Goulette, exterior de la valva derecha e interior de la valva izquierda, tamaño real 4,3 mm.*

Synonymie en usage: *Musculus marmoratus* (Forbes, 1844)
Référence à des descriptions publiées: Tebble, 1966, p. 46-47, sous le nom de *Musculus marmoratus*); Gofas, Moreno et Salas, 2011, p. 569.

Cette espèce se caractérise par une coquille de petite taille, jusqu'à 10 mm, fragile, ovalaire a subquadrangulaire, renflée. Les crochets sont arrondis et situés assez près de l'extrémité antérieure. La sculpture externe est formée par 6-8 fines côtes radiales sur l'extrémité antérieure, une zone lisse au milieu et environ 15-20 côtes radiales très aplaties dans la moitié postérieure. La coloration externe est verdâtre avec des taches ou lignes en zig-zag de couleur brune, intérieur un peu nacré, laissant voir la couleur externe par transparence.

Cette espèce est signalée pour la première fois sur le littoral de Tunisie et se trouve ici prédominante sur les fonds meubles. Les adultes de cette espèce sont souvent trouvés insérés dans la tunique d'ascidies (GOFAS ET AL., 2011) ce qui n'a pas été observé dans le présent matériel. L'espèce a une très large distribution, en Méditerranée et dans l'Atlantique, de la Norvège à la Mauritanie et en Angola, ainsi que dans les îles Canaries et du Cap Vert.

Parvicardium scriptum (Bucquoy, Dautzenberg et Dollfus, 1892) (Fig. 12)

Référence originale: *Cardium exiguum* var. *scripta* Bucquoy, Dautzenberg et Dollfus, 1892 *Les mollusques marins du Roussillon. Tome II. Pélécypodes*, p. 283, pl. 45 fig. 13-18 [Localité type: Méditerranée]
Référence à des descriptions publiées: van Aartsen et Goud, 2000; Scaperrota et al., 2011, p. 139; Gofas, Moreno et Salas, 2011, p. 628.

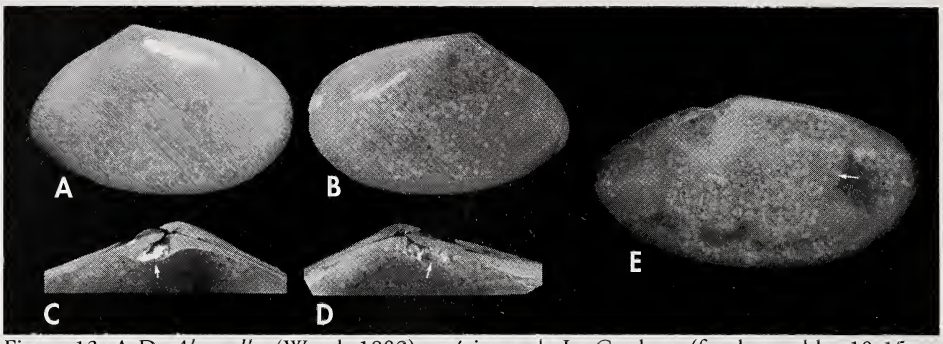

Figure 13. A-D. *Abra alba* (Wood, 1802), spécimen de La Goulette (fonds meubles 10-15 m, 22.02.2010). A, B: extérieur et intérieur de la valve droite; C, D: détail de la charnière, montrant le très grand chondrophore oblique (flèches). Taille réelle 10,3 mm. E. *Abra nitida* (Müller O.F., 1776) spécimen juvénile de La Goulette (fonds meubles 10-15 m, 29.06.2009), vu de la valve droite. Taille réelle 2,8 mm; on distingue par transparence un des palpes labiaux (flèche), très développé comme il est prévisible chez une espèce détritivore.

Figura 13. A-D. Abra alba *(Wood, 1802), ejemplar de La Goulette (fondos blandos de 10-15 m, 22.02.2010). A, B: exterior e interior de la valva derecha; C, D: detalle de la charnela, mostrando el condróforo oblicuo (flechas) muy desarrollado. Tamaño real 10,3 mm. E.* Abra nitida *(Müller, 1776) ejemplar juvenil de La Goulette (fondos de 10-15 m, 29.06.2009), visto desde la valva derecha. Tamaño real 2,8 mm; se pueden apreciar por transparencia los palpos labiales (flecha), muy desarrollados como se puede esperar en una especie detritívora.*

Cette espèce se caractérise par une coquille petite, solide, jusqu'à 10 mm, de forme ovale, inéquilatérale, avec le bord postérieur arrondi. La sculpture externe est formée par environ 25 côtes radiales, celles des portions antérieure et postérieure portant quelques tubercules. La couleur externe est blanchâtre avec des taches ou une zone brun verdâtre dans la portion postérieure, l'intérieur blanc avec des taches brunes.

Cette espèce ressemble le plus à *Parvicardium exiguum* (Gmelin, 1791) (Fig. 12 A-D) dont elle a été à l'origine considérée comme une variété. Elle s'en différencie essentiellement par le contour plus régulièrement ovale, la forme plus allongée et la couleur de fond plus blanche. C'est une nouvelle signalisation sous ce nom pour la Tunisie, mais en fait elle a probablement été confondue précédemment avec *P. exiguum*. L'espèce est liée au biotope des Algues Photophiles sur fonds rocheux, contrairement à *P. exiguum* qui se trouve plutôt sur des fonds meubles plus ou moins envasés, en mode calme, et se trouve fréquemment dans notre matériel de 3-4 m et 10-15 m à La Goulette. *Parvicardium scriptum* vit en Méditerranée, et dans l'Atlantique du sud du Portugal au Maroc, et aux îles Canaries.

Abra nitida (Müller O.F., 1776) (Fig. 13)

Référence originale: *Mya nitida* O.F. Müller, *Zoologiae Danicae prodromus*, p. 245. [Localité type: non spécifiée, Norvège ou Danemark]

Référence à des descriptions publiées: Tebble, 1966, p. 152-153; Gofas, Moreno et Salas, 2011, p. 654.

Cette espèce se caratérise par une coquille de petite taille, entièrement blanche, jusqu'à 10 mm de long, fragile et délicate, translucide, modérément convexe, à peine inéquilatérale avec le crochet un peu postérieur. La sculpture

est très ténue, essentiellement formée par les stries d'accroissement. Le sinus palléal est extrêmement large, s'étendant dorsalement jusqu'assez près de l'umbo, le bord ventral partiellement confluant avec la ligne palléale. Cette espèce est beaucoup plus petite, allongée et aplatie, avec une coquille plus fine et plus translucide, que *Abra alba* (Wood, 1802) (Fig. 13 A-D) qui est l'espèce la plus habituelle également trouvée à La Goulette.

Cette espèce est signalée pour la première fois en Tunisie et de trouve distribuée en Méditerranée et dans l'Atlantique, de la Norvège au Maroc.

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Dendrodoris limbata (Cuvier, 1804)

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Ros J. 1976. Catálogo provisional de los Opistobranquios (Gastropoda: Euthyneura) de las costas ibéricas. *Miscelánea Zoológica*, 3 (5): 21-51.

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Synonyms

Doris limbata Cuvier, 1804, *Ann. Mus. Hist. Nat. Paris*, 4 (24): 468-469 [Type locality: Marseille].

Doris nigricans Otto, 1823, *Nov. Act. Ac. Caes. Leop.-Car.*, 10: 275.

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ÍNDICE

Iberus 30 (2) 2012

BOGI C., KARHAN S.Ü. AND YOKEŞ M.B. *Oscilla galilae*, a new species of Pyramidellidae (Mollusca, Gastropoda, Heterobranchia) from the Eastern Mediterranean
Oscilla galilae, *una nueva especie de Pyramidellidae (Mollusca, Gastropoda, Heterobranchia) del Mediterráneo oriental* 1-6

HOLYOAK D.T., HOLYOAK G.A. AND TORRES ALBA J.S. A reassessment of the species of *Truncatellina* (Gastropoda: Vertiginidae) in the Iberian Peninsula and North-west Africa
Revisión de las especies de Truncatellina *(Gastropoda: Vertiginidae) en la Península Ibérica y NO de África* 7-33

ROLÁN E. AND RUBIO F. A new species and range extension of *Ponderinella* (Gastropoda, Tornidae) in West Africa
Una nueva especie y extensión del área de Ponderinella *(Gastropoda, Tornidae) en África occidental* 35-39

GOFAS S. A new species of *Bornia* (Bivalvia: Galeommatoidea) from southern Spain
Una nueva especie de Bornia *(Bivalvia: Galeommatoidea) del sur de España* 41-48

OLIVER J.D., TEMPLADO J. Y KERSTING D. Gasterópodos marinos de las islas Columbretes (Mediterráneo occidental)
Marine gastropods of the Columbretes Islands (Western Mediterranean) 49-87

TEMPLADO J. AND ROLÁN E. A new species of *Phorcus* (Vetigastropoda, Trochidae) from the Cape Verde Islands
Una nueva especie de Phorcus *(Vetigastropoda, Trochidae) del archipiélago de Cabo Verde* 89-96

LEFRERE L., MOUKRIM A., IDARDARE Z., BERGAYOU H. AND KAAYA A. Reproductive cycle of *Scrobicularia plana* (da Costa, 1778) (Bivalvia: Semelidae) in two Moroccan lagoons: Khnifiss and Oualidia
Ciclo reproductor de Scrobicularia plana *(da Costa, 1778) (Bivalvia: Semelidae) en dos lagunas marroquíes: Khnifiss y Oualidia* 97-106

ANTIT M. ET AZZOUNA A. Mollusques des milieux littoraux de la baie de Tunis
Moluscos de hábitats litorales de la bahía de Túnez 107-133

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Vol. 31 (1)

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Iberus gualtieranus (Linnaeus, 1758), una especie emblemática de la península Ibérica, que da nombre a la revista. Dibujo realizado por José Luis González Rebollar "Toza".

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Some new species of Skeneinae (Prosobranchia, Turbinidae)

Algunas nuevas especies de Skeneinae (Prosobranchia, Turbinidae)

Federico RUBIO* and Emilio ROLÁN**

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RESUMEN

Se describen tres especies nuevas de aguas profundas pertenecientes a la subfamilia Skeneinae y a los géneros *Trenchia* (dos especies) y *Lissotesta* (una especie). Se muestran sus caracteres morfológicos y se comparan con otras especies congenéricas y con otros gasterópodos "skeneiformes" de similar morfología.

ABSTRACT

Three new deep water species belonging to the subfamily Skeneinae are described. Two are placed in genus *Trenchia* and one in *Lissotesta*. Their morphological characters are shown and they are compared with other congeneric species and with other "skeneimorph" gastropods of similar morphology.

INTRODUCTION

The subfamily Skeneinae Clark, 1851 is formed by numerous genera with small sized species. Hickman & McLean (1990) placed it as family Skeneidae Clark, 1851 in the superfamily Trochacea Rafinesque, 1815, but Bouchet & Rocroi (2005) moved it to Turbinidae Rafinesque, 1815, with subfamily rank.

These molluscs are always small (1-3 mm) and frequently inhabit very deep water, both facts causing them to have been scarcely studied so far.

In very fine sediments that the authors obtained from deep water dredgings (Rolán & Pérez-Gándaras, 1981; Peñas, Rolán, Luque, Templado, Moreno, Rubio, Salas, Sierra & Gofas, 2006) some apparently unknown shells were found. After their study, we concluded that some of them are new to science and they are described in the present paper.

Abbreviations

MNCN Museo Nacional de Ciencias Naturales, Madrid
CFS collection of Frank Swinnen
H/D ratio of height/diameter

SYSTEMATIC PART

Family Turbinidae Rafinesque, 1915
Subfamily Skeneinae W. Clark, 1851

Genus *Trenchia* Knudsen, 1964

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Trenchia Knudsen, 1964. *Galathea Reports* 7: 129, fig. 5 A-C. [Type species by original designation: *Trenchia wolffi* Knudsen, 1964]. Recent.

Diagnosis: A genus belonging to the Turbinidae, having a small conical shell, a relatively large aperture, a thin horny operculum and a rhipidoglossate radula with two lateral and numerous marginal teeth.

Remarks: KNUDSEN (1964: 129), on the basis of radular morphology, places his new genus in the family Trochidae, subfamily Margaritinae. WARÉN & BOUCHET (1993) consider the systematic position of *Trenchia* in the subfamily Skeneinae (Turbinidae); they mention that the genera *Trenchia* and *Ventsia* Warén & Bouchet, 1993 are close, and that their species have similar shells and radulae (the soft parts being unknown) but different protoconchs; to show this, they present SEM photographs of the holotype of *Trenchia wolffi* and the protoconch of an undescribed European species. Recently, while the genus *Trenchia* is kept in Skeneinae, placement of the genus *Ventsia* has been suggested in the Seguenzioidea (KUNZE, HEß & HASZPRUNAR, 2008), without assigned family.

Two species are currently known in the genus *Trenchia*: *T. wolffi* Knudsen, 1964 from Kermadec Trench, South Pacific Ocean and *T. argentinae* (Clarke, 1961) from the Argentine Basin, South Atlantic Ocean. Both are abyssal species dredged between 4000 and 6000 m in depth. The new species here described came from Atlantic Seamounts (Sedio, Seine, Ampère and Galicia), which have their upper part at depths between 60 and 1000 m, or they are from coralline bottom between 80 and 200 m (Alborán Island).

Closely related genera are *Ventsia* and *Xyloskenea* Marshall, 1988. Each genus has a characteristic protoconch which diagnoses the generic position of each species:

- *Ventsia* species have a protoconch about 300 µm in width, with two parts; the initial has 5 spiral threads and the second part has short axial riblets and a strong spiral carina interrupted by a strong labial varix.

- *Xyloskenea* species have a protoconch with 200-267 µm width, with 4-6 fine spiral threads, thereafter smooth or granulate and 1-2 rounded axial pleats immediately behind the apertural rim. WARÉN (1996: 202-204, figs. 3A-B, 7C) redescribed the European species *Cithna naticiformis* Jeffreys, 1883, placed it in *Xyloskenea* and considered it as being to some extent intermediate between *Xyloskenea* and *Trenchia* by having the same protoconch sculpture as *Xyloskenea* ut a smooth teleoconch like *Trenchia*.

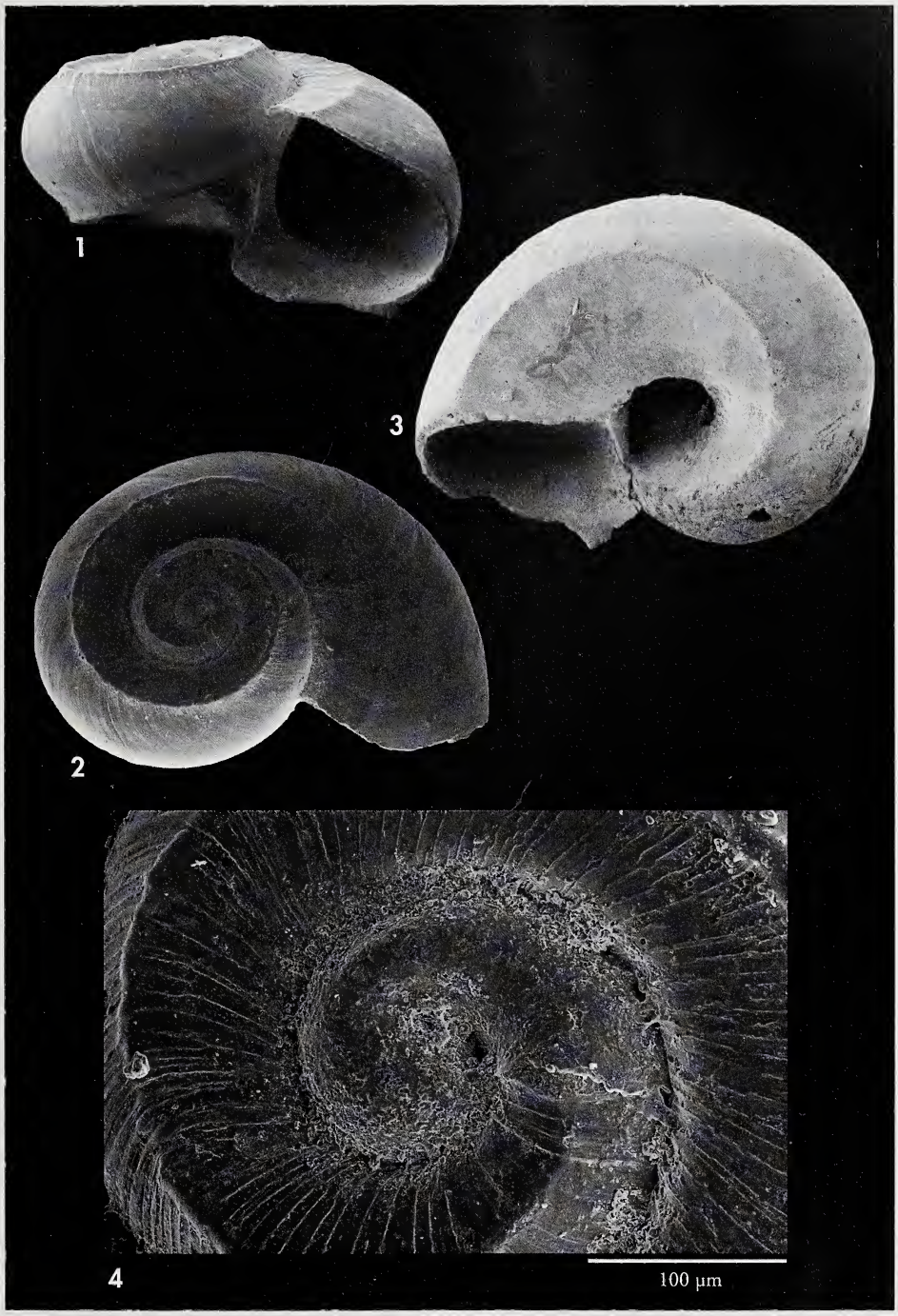
- *Trenchia* has a protoconch of 350 µm in width, glassy and devoid of any sculpture in the type species (KNUDSEN, 1964).

Trenchia biangulata n. sp. (Figures 1-6)

Trenchia sp. Beck, Metzger & Freiwald, 2002. BIAS: Biodiversity Inventorial Atlas of Macrobenthic Seamount Animals (*Deliverable 25 of the EU-ESF project OASIS* (Oceanic seamounts: an integrated study; EVK2-CT-2002-00073) [online]: 51.

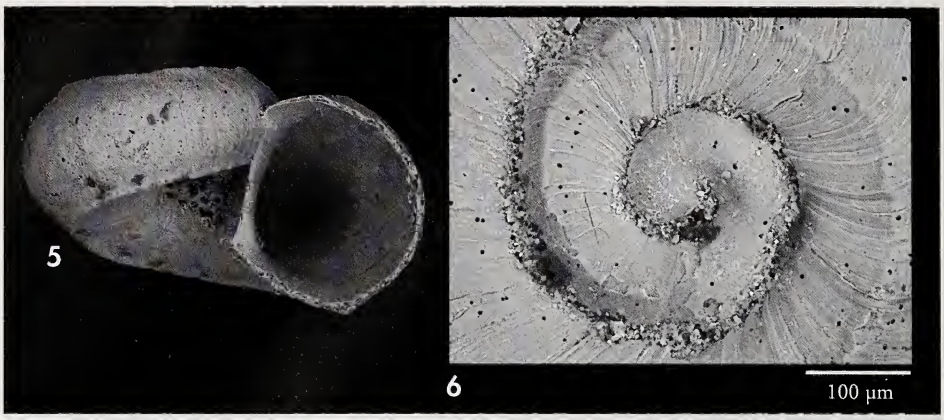
Type material: Holotype 15.05/60064H (Fig. 3) and 1 paratype 15.05/60064P (Figs. 1-2) in MNCN.
Other material examined: 1 s, Salvage Islands, 600-700 m (CFS, Fig. 5-6); 1 s, Expedition Bautismal 9812, est. 16, Punta Toston, Gran Canaria, 28° 46.474′ N - 13° 59.921′ W, 400 m (CFS).
Type locality: Galicia Seamount (42° 67′ N, 11° 74′ W), 200 km off north-western Spain, 800-1000 m.
Etymology: The specific name refers to the two spiral angulations present in the dorsal and ventral areas of the shell.

Description: Shell of very small size (<1.5 mm), of low spire, with periphery rounded and strongly carinate above and below. The protoconch has only one whorl,



Figures 1-4. *Trenchia biangulata* n. sp. 1, 2: holotype, 1.27 mm in diameter (MNCN); 3: paratype, 1.2 mm in diameter, Galicia Seamount (42° 67' N, 11° 74' W) (MNCN); 4: protoconch of the holotype.

Figuras 1-4. Trenchia biangulata *n. sp. 1, 2: holotipo, 1,27 mm en diámetro (MNCN); 3: paratipo, 1,2 mm en diámetro, Banco de Galicia (42° 67' N, 11° 74' W) (MNCN); 4: protoconcha del holotipo.*



Figures 5, 6. *Trenchia biangulata* n. sp., Salvage Islands, shell, 1.2 mm in diameter, and protoconch.
Figuras 5, 6. Trenchia biangulata *n. sp., Islas Salvajes, concha, de 1,2 mm de diámetro y protoconcha.*

measuring approximately 200 µm; its surface is rough and presents an elevation in the middle forming an angle. The teleoconch has 2 whorls of rapid growth and is ornamented by two spiral carinae and with growth lines. These carinae are thick and high, forming angles on the shell, one next to the suture and the other near the base; the space between them, the periphery, is strongly convex. The entire surface of the teleoconch is covered with fine growth lines, more marked in the sutural area of the first whorl, which are undulating on the periphery of the shell. Umbilicus narrow and deep, markedly delimited by the angle of a raised umbilical cord. Aperture large and obliquely D-shaped. Columella straight, not very thick and slightly reflected towards the umbilicus, wider in the area of crossing between the outer lip and the umbilical cord.

Dimensions of the holotype: 1.27 mm diameter and 0.78 mm in height (H/D: 0.61).

Habitat: The species was recorded as a member of the macrofaunal seamount community; bathymetric range 59 to 750 m deep (Beck, Metzger & Freiwald, 2006). The shell collected in Salvage Islands was dredged between 500 and 700 m; those from the Galician Bank were collected in white coralline bottom at a depth of 700-1000 m.

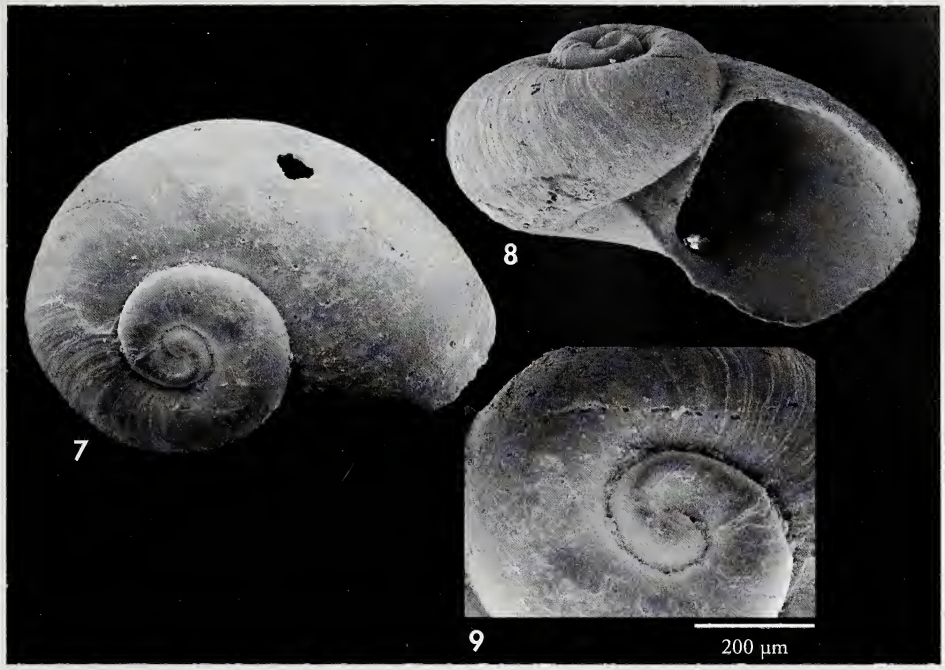
Distribution: Found on Sedlo Seamount (40° 25′ N - 26° 55′ W) north of the Azores; Seine Seamount (33° 50′ N - 14° 20′ W) and Ampère Seamount, both off Portugal (Beck *et al.*, 2006); Canary and Salvage Islands; Galicia Seamount off Galicia coasts, north-western Spain (this paper).

Remarks: Warén & Bouchet (1993: 24, fig. 18H) figured the protoconch of a unidentified European species of *Trenchia* from Bay of Biscay, perhaps conspecific with *T. wolffi*. This protoconch is similar to that of *T. biangulata* but is wider (300 µm).

T. biangulata n. sp. is very similar in general shape to *T. wolffi* and *T. argentinae*, being distinguished from them by its smaller shell (<1.5mm), lower spire, more elevated spiral carinae, raised umbilical cord and narrower umbilicus.

Xyloskenea naticiformis (Jeffreys, 1883) and *Xyloskenea xenos* Hoffman, Van Heugten & Lavaleye, 2010 are the only known species of *Xyloskenea* in the NE Atlantic; both species differ from *T. biangulata* in their different protoconch and by lacking the carina along the spire.

Xyloskenea translucens (Dall, 1927) and *Xyloskenea rhyssa* (Dall, 1927) from the NW Atlantic (see Rubio, Fernández-Garcés & Rolán, 2011, figs 119 and 120) have the protoconch with spiral threads, typical of the genus *Xyloskenea*, contrary to that of *Trenchia biangulata* (Figs. 4 and 6) whose surface is rough and presents an elevation in the middle forming an angle, and also has a larger diameter.



Figures 7-9. *Trenchia anselmoi* n. sp. 7, 8: holotype, 1.5 mm in diameter, Alboran Island (MNCN); 9: protoconch.
Figuras 7-9. Trenchia anselmoi *n. sp. 7, 8: holotipo, 1,5 mm en diámetro, Isla de Alborán (MNCN); 9: protoconcha.*

Trenchia anselmoi n. sp. (Figures 7-9)

Type material: Holotype deposited in MNCN (15.05/60065).
Type locality: Alboran Island, coralligenous, 80-200 m.
Etymology: The specific name is after Anselmo Peñas, malacologist of Vilanova i la Geltrú who collected the holotype in sediments from Alboran.

Description: Shell of very small size (1.5 mm), wider than high, spire formed by barely 2.5 whorls of rapid growth. Protoconch near ¾ of whorl, measuring 260 µm in diameter, with a finely roughened surface and in its middle area an elevation forming an angle. The teleoconch has 1 ¾ whorl, and is completely smooth except for a thick, raised umbilical cord and rough, very tight and sinuous growth lines. Aperture relatively large, D-shaped; the outer lip is sharp and connected with the parietal wall posteriorly at an angle of about 90°; columella opisthocline, straight, slightly angled at the insertion site with outer lip and umbilical cord. Umbilicus narrow and deep occluded by the angle with the umbilical cord extension.

Dimensions of the holotype: 1.5 mm diameter and 1.0 mm height (H/D: 0.67).

Habitat: Collected between 80 and 200 m deep, in sediments from the coralligenous bottoms near Alboran Island.

Distribution: Only known from Alboran Island, its type locality.

Remarks: Its general shape, the protoconch, the D-shaped aperture and the umbilical cord extended at an angle are the main reasons for the placement of this species in the genus *Trenchia*.

Trenchia anselmoi n. sp. can be distinguished from *T. wolfii*, *T. argentinae* and

T. biangulata because its teleoconch lacks any spiral carinae. It may be distinguished from the European species *Xyloskenea naticiformis* and from juveniles of *Choristella nofronii* McLean, 1992 by the different ornamentation of the protoconch and by the presence of a keel on the basal area,, surrounding a broad, funnel shaped umbilicus. From *Xyloskenea rhyssa*, it may be differentiated by the different ornamentation of the protoconch and lack of axial sculpture (see RUBIO *ET AL.*, 2011, Fig. 119).

Xyloskenea xenos Hoffman, van Heugten & Lavaleye, 2010 has a shell which is more elevated. In the original description it is mentioned that the diameter of the protoconch is about 160 µm but the figure of the protoconch with the scale in it included could represent a diameter of about 300 µm, in any case different to the size of our species. The protoconch of our species has an elevation along this part, while in *X. xenos* it is only present in a short part (see figure 30 in the original description).

Genus *Lissotesta* Iredale, 1915

Lissotesta Iredale, 1915. *Transactions of the New Zealand Institute*, 47: 442. [Type species by original designation: *Cyclostrema micra* Tennison-Woods, 1877. Tasmania. Recent].

Intortia Egorova, 1972. *Issledovaniya Fauny Morej*, 19: 386. [Type species by original designation: *I. homocostata* Egorova, 1972. Antartic].

Diagnosis: WARÉN (1992: 169) describes this genus as: "Very small, globular gastropods, usually with a characteristic larval shell covered by an outer coating of, usually, finely granular, calcium carbonate which makes the suture almost invisible, except by transparency. 2-3 well rounded teleoconch whorls and a deep umbilicus with internal ridges. Radula with central tooth, one small inner and a larger outer lateral tooth and about five, basally united, flagelliform marginals".

Remarks: There are four European species in the genus *Lissotesta*: *L. minima* (Seguenza, 1876), *L. gittenbergeri* (van Aartsen & Bogi, 1988), *L. turrita* (Gaglini, 1987) and *L. major* Warén, 1992.

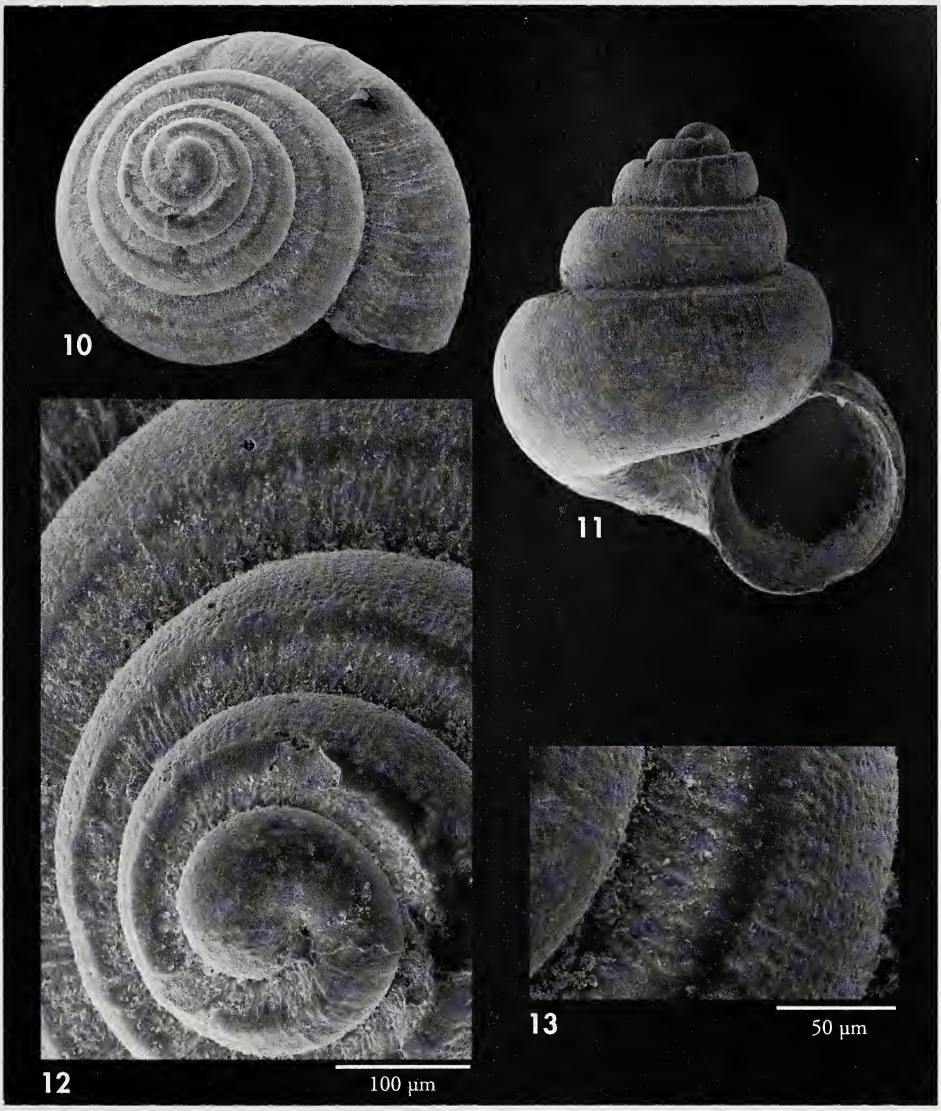
A very characteristic feature of the species of *Lissotesta* is the protoconch, which is large and swollen, dome-shaped, usually with a granular sculpture and lacking almost any trace of coiling. About *L. minima*, WARÉN (1992: 169) writes: "*L. minima* (Seguenza, 1876) is here included in *Lissotesta* although it does not fit and will probably need a new genus when this group is better known. Presently I hesitate to propose a new genus for this featureless shell, which I place in *Lissotesta* because it has a similar umbilicus and shape".

Lissotesta scalaroides n. sp. (Figs. 10-13)

Type material: Holotype (Figs. 10-13) deposited in MNCN (15.05/60061).
Type locality: Galicia Seamount (42° 67′ N, 11° 74′ W), 200 km off Galicia coasts, north-western Spain.
Etymology: The specific name refers to the stepped shape of the spire.

Description: Skeneimorph shell, very small (<1.5 mm), with robust aspect and a scalariform appearance. The protoconch measures 170 µm in diameter, has ¾ of a whorl, and its surface is covered with a fine granular sculpture. Teleoconch consisting of up to 3 ¾ convex whorls, completely covered with spirally aligned micro pits and growth lines.

From the suture at the beginning of the periphery there is a flat area, although slightly inclined, which runs throughout the spire and gives the shell



Figures 10-13. *Lissotesta scalaroides* n. sp. 10-11: holotype, 1.11 mm in height, Galicia Seamount (42°67'N-11°74'W) northwestern Spain (MNCN); 12: protoconch; 13: microsculpture.
Figuras 10-13. Lissotesta scalaroides *n. sp. 10-11: holotipo, 1,11 mm de altura, Banco de Galicia (42°67'N-11°74'W) noroeste de España (MNCN); 12: protoconcha; 13: microescultura.*

its scalariform appearance; it disappears in the last quarter whorl apparently by a fracture on the surface of the shell. One strong and sharp spiral cord around and inside the umbilicus. Aperture rounded, prosocline; outer lip not modified or thickened, columella thin and reflected outwardly. Umbilicus narrow and deep.

Dimensions of the holotype: 0.96 mm in diameter; 1.11 mm in height (H/D: 1.15).

Hábitat: The studied shell is from a white coralline bottom dredged at a depth of 700-1000 m.

Distribution: Only known from Galicia Seamount (42° 67′ N, 11° 74′ W),

200 km off Galicia coasts, north-western Spain.

Remarks: The surface totally covered by spirally aligned micro pits, growth lines and a thick spiral cord that is located around and inside the umbilicus, characterize the shell of *Lissotesta scalaroides* and differentiate it from its congeneric species. The present species, as well as *Lissotesta minima* (Seguenza, 1876), does not have the characteristic protoconch of most of the species in this genus, which is "large and swollen, dome-shaped, usually with a granular sculpture and lacking almost every trace of coiling". According to Warén (1992), a possibility would be to create a new genus for *"Lissotesta" minima*, in which could be placed the species now described, since both species present characters in the protoconch that make them different from the rest of species currently considered congeneric. However the lack of knowledge of their soft parts and radula prevents us at present to do this.

Lissotesta scalaroides n. sp. has a general shape very similar to *Mikro hattonensis* Hoffman, Van Heugten & Lavaleye, 2010 from Hatton Bank, from which our new species may be distinguished by having a larger diameter of the protoconch (170 versus 130 µm), by the micropits which totally cover the teleoconch (not only the top of the whorls), by lacking a true keel in the umbilicus, and having microsculpture extending into this infundibulum.

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Jesús Méndez of the Centro de Apoyo Científico y Tecnológico a la Investigación (CACTI) of the University of Vigo made the SEM photographs. Frank Swinnen and Anselmo Peñas loaned material for study. APROPESCA sponsored the dredgings in Galicia Bank. António A. Monteiro revised the English text.

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A revision of the Mediterranean Raphitomidae 2: On the sibling species *Raphitoma lineolata* (B.D.D., 1883) and *Raphitoma smriglioi* n. sp.

Revisión de los Raphitomidae del Mediterráneo (Conoidea) 2: las especies hermanas *Raphitoma lineolata* (B.D.D., 1883) y *Raphitoma smriglioi* n. sp. (Gastropoda, Conoidea)

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ABSTRACT

A new raphitomid toxoglossan, *Raphitoma smriglioi* Pusateri & Giannuzzi-Savelli n. sp., is described from the Mediterranean Sea. It is the sister species of *Raphitoma lineolata* (B.D.D., 1883), from which it differs in the different protoconch (paucispiral v. multispiral), adding to a long list of pairs of caenogastropod species differing in their larval development.

RESUMEN

Una nueva especie de toxogloso rafitómido, *Raphitoma smriglioi* Pusateri & Giannuzzi-Savelli n. sp., se describe del Mediterraneo. Es especie hermana de *Raphitoma lineolata* (B.D.D., 1883), de la cual se diferencia por su protoconcha (pauciespiral vs. multispiral) y se suma a una larga lista de parejas de especies que difieren en su desarrollo larvario (planctotrófico vs. no-planctotrófico).

INTRODUCTION

The Raphitomidae are currently considered as a well supported clade of the Conoidea (Bouchet, Kantor, Sysoev & Puillandre, 2011). The taxon Raphitomidae Bellardi 1875 is based on the genus *Raphitoma* Bellardi, 1847 which was introduced as comprising 30 fossil and Recent species (Bellardi, 1847: 85), previously classified in various genera (such as *Pleurotoma* and *Clathurella*). Among the modern Authors, Nordsieck (1977) listed 30 European species plus several subspecies and varieties. In the revision of the Mediterranean Raphitomidae that we are currently carrying out, we estimated ca. 40 Mediterranean species, some of which are new.

Propaedeutic to the main revision, we have focused on several pairs of species, differing only or mostly in the size and shape of the protoconch. The specific distinction is based on the assumption that the dichotomy multispiral protoconch/planktrotrophic develop-

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ment vs. paucispiral protoconch/lecithotrophic development (Jablonski & Lutz, 1980) can be used in caenogastropods to recognise distinct sister species (Bouchet, 1989; Oliverio, 1996a, 1996b, 1997), however, it should not be abused to create polyphyletic genera by artificially separating closely related species among different genera only based on their larval development (Bouchet, 1990). In the genus *Raphitoma* Bellardi, 1847, we have scored at least eleven such pairs of species with different protoconchs (multispiral vs. paucispiral: Tab. 1). Nine pairs still pose intricate taxonomical problems to be solved before a thorough revision of all Mediterranean pairs can be published in a forthcoming paper. In a previous paper (Pusateri, Giannuzzi-Savelli & Oliverio, 2012) we have dealt with the rather obscure taxon *Raphitoma contigua* (Monterosato, 1884), of which we have selected a lectotype with multispiral protoconch to stabilize the usage of the name, and with its sister species with paucispiral protoconch, therein described as *R. spadiana* Pusateri & Giannuzzi-Savelli, 2012. In the present work we present the results on another pair: *Raphitoma lineolata* (B.D.D., 1883) is supposed to be a relatively well known species, yet specimens with indistinguishable teleoconchs and different protoconchs (multispirals and paucispiral) are found throughout its putative range. Since the original type material has not been found, a neotype is here designated to stabilize the use of the name *Clathurella purpurea* var. *lineolata* B.D.D., 1883 based on a specimen with multispiral protoconch, and the species with paucispiral protoconch is described as new.

Abbreviations:

MNHN = Muséum National d'Histoire Naturelle (Paris, France)
SMNH = Swedish Museum of Natural History (Stockholm, Sweden)
MCZR = Museo Civico di Zoologia di Roma (Italy)
HUJ = Hebrew University of Jerusalem (Israel)
IRSNB = Institut Royal des Sciences Naturelles de Belgique, Bruxelles
SMF = Senckenberg Museum, Frankfurt/M (Germany)

SYSTEMATICS (Citation of unpublished names is not intended for taxonomic purposes)

Family Raphitomidae Bellardi, 1875

Genus *Raphitoma* Bellardi, 1847

Type species: *Pleurotoma hystrix* Cristofori and Jan, 1832 (*nomen nudum*, validated by Bellardi, 1847 as "*Pleurotoma histrix* Jan.") by subsequent designation (Monterosato, 1872: 54).

Raphitoma lineolata (B.D.D., 1883) (Figures 1-10, 19, 20)

Clathurella purpurea var. *lineolata* B.D.D., 1883: 92.
Raphitoma (Philbertia) purpurea var. *lineolata* B.D.D., Nordsieck, 1968: 177
Raphitoma purpurea var. *lineolata* (B.D.D.), Parenzan, 1970: 208
Raphitoma (Philbertia) lineolata (B.D.D, 1882 [sic!]), Nordsieck, 1977: 54, pl. 17, fig. 133
Raphitoma (Philbertia) lineolata fuscata, Nordsieck, 1977: 54, pl. 17, fig.
Raphitoma (Philbertia) flavida Nordsieck, 1977: 54 (partim)
Raphitoma (Philbertia) corbis sensu Nordsieck, 1977 (partim) non Michaud, 1838
Raphitoma lineolata (B.D.D., 1882 [sic!]), Bogi, Coppini & Margelli, 1980: 18 figs 9-10
Raphitoma lineolata (B.D.D., 1882 [sic!]), Rolán, 1983: 270, fig. 257
Raphitoma lineolata (B.D.D., 1883), Cecalupo & Quadri, 1996: 109
Raphitoma lineolata (B.D.D., 1883), Doneddu & Trainito, 2005: 149 (fig. 361)
Raphitoma lineolata (B.D.D., 1883), Repetto, Orlando & Arduino, 2005: 219, fig. 902
Raphitoma lineolata (B.D.D., 1883), Cossignani & Ardovini, 2011: 326-327

Type material: *Clathurella purpurea* var. *lineolata* neotype here designated, MNHN, St. Raphael (Var), France, heigth 7,2 mm, width: 2,9 mm. *Raphitoma (Philbertia) lineolata fuscata* Nordsieck, 1977 (SMF, not examined) *Raphitoma (Philbertia) flavida* Nordsieck, 1977 (Ibiza, 12 shells, SMF 337099/14, 14 syntypes, including 9 shells of *R. densa*, 3 shells of the *R. bicolor*-complex, 1 shell of *R. lineolata*, 1 shell of *R.* cf. *corbis*)

Other material examined: Unless otherwise stated, the shells originated after sorting bioclastic sands collected between 0-40 m depth. Spain - Punta de la Mona, Malaga, (coll. Bartolini, 18 shells); Marbella (coll. Gubbioli, 2 shells); Estepona (coll. Rufini 1 shell); Algeciras (SMNH, lot 73168C, 1 shell); Ceuta North (MNHN, 1 shell); Ibiza (coll. Nordsieck, SMF 337090/4, 337091/3 and 337090/9 sub nomine *Philbertia corbis* 14 shells). France - St. Jean de Luz, Pyrénées-Atlantiques (MNHN, coll. H. Fischer, 1 shell); Le Brusc, Var (MNHN, 1 shell); Iles Embiez, Var (MNHN, 4 shells); Calvi, Corsica (SMNH, 52 specimens, lots 73171I, 73171M; coll. Pusateri, 2 shells). Bastia, Corsica (coll. Margelli, 1 shell; MCZR, coll. Monterosato, lot 16786, 2 shells). Croatia – Verunic (coll. Pusateri 2 shell); Veli Rat (coll. Melvill-Tomlin, NMW lot 12919, sub nomine ms. "Philbertia subtilis" Monterosato, 5 shells); Krk Is. (coll. Bartolini, 5 shells); unspecified locality, Croatia (coll. Delemarre, 4 shells). Italy - Riva Trigoso (Ge) -20 m, Liguria (coll. Sossu, 5 shells; coll. Repetto, 2 shells); Boccadasse (Ge) -50 m, Liguria (coll. Repetto 1 shell); Castiglioncello (Li), Tuscany (coll. Margelli, 8 shells; coll. Balena, 3 shells); Bagni Fiume (Li), Tuscany (coll. Margelli, 1 shell); Gorgona Is., Tuscany (coll. Balena, 1 shell). Giglio Is., Tuscany (coll. Balena, 1 shell); Gulf of Baratti, Tuscany (coll. Balena, 8 shells; coll. Nofroni, 1 shell); Giannutri Is., Tuscany (coll. Agamennone, 2 shells; coll. Smriglio, 3 shells); Antignano (Li), Tuscany (coll. Gori, 1 shell). Calambrone (Pi), Tuscany (coll. Bartolini, 4 shells); Montalto di Castro (Vt), Latium (coll. Occhipinti 5 shells); Capo Linaro (Rm), Latium (coll. Rufini 1 shell); Nettuno (Rm), Latium (coll. Occhipinti 1 shell). Capri Is., Campania (coll. Coen, Jerusalem, 11218 sub nomine ms. "Philbertia purpurea mitis M." 1 shell). Campomarino, Apulia (coll. Di Niso, 1 shell); Porto S. Caterina (Nardò), Apulia (coll. Bini 1 shell); Otranto channel, Apulia (coll. Trono, 1 shell); Novaglie, Apulia (coll. Macrì, 1 shell); Scilla, Calabria (coll. Vazzana, 11 shells). La Maddalena Is., Sardinia (coll. Rufini 3 shells); Ennio Falco cave, Portoconte, Sassari, Sardinia (coll. Oliverio, 3 shells); Stintino (Sassari), Sardinia (coll. Rufini 1 shell); Tres Nuraghes, Oristano, Sardinia (coll. Palmeri, 1 shell); S'Archittu (Oristano), Sardinia (coll. Sossu, 15 shells); Porto Istana (Olbia), Sardinia (coll. Doneddu 1 shell); Porto Alabe (Nuoro), Sardinia (coll. Spanu, 5 shells); Alghero, Sardinia (coll. Spanu, 1 shell, coll. Occhipinti, 1 shell). Palermo, Sicily (coll. Monterosato, MCZR 16678a, 1 shell; MCZR 16786, 4 shells + 2 shells sub nomine ms. "acuminata"; MCZR 16808, 8 shells sub nomine ms. "subtilis"); Carini (Palermo), Sicily (coll. Monterosato MCZR n. 16793 1 shell ; MCZR n. 16808, 1 shell); Isola delle Femmine (Palermo), Sicily (coll. Palmeri, 3 shells; coll. Sercia 1 shell); Ficarazzi, Sicily (Palermo) (coll. Pusateri 12 shells); Trapani, Sicily (coll. Occhipinti 1 shell); Lo Scalone, Messina, Sicily (coll. Bartolini, 4 shells); Ustica Is. (coll. Villari 3 shells). Acitrezza, Isola Lachea, Sicily (SMNH 73197B, 9 shells juv.); Acitrezza (Catania), Sicily (SMNH 73097B, 1 shell); Cannizzaro (Catania), Sicily (coll. Rufini 3 shells); Ognina (Catania), Sicily (coll. Gemanà 1 shell). Marzamemi (Siracusa), Sicily (coll. Germanà 1 shell); Capo Passero (Siracusa), Sicily (coll. Margelli, 1 shell); Porto Palo (Siracusa), Sicily (coll. Germanà 3 shells); Pantelleria Is. (coll. Bartolini, 2 shells); Lampedusa Is. (coll. Agamennone, 1 shell); Lipari Is. (coll. Monterosato MCZR 16877, 1 shell). Malta – unspecified locality (coll. Mifsud, 5 shells). Wied Iz Zurrieg (coll. A.R. Arthur, 1 shell). Tunisia - Sfax (coll. Staadt, MNHN, 1 shell). Cyprus – off Larnaka, - 42 m (coll. Bartolini, 1 shell). Turkey – Adana (coll. Can Geyran Seashell Center, 1 shell).

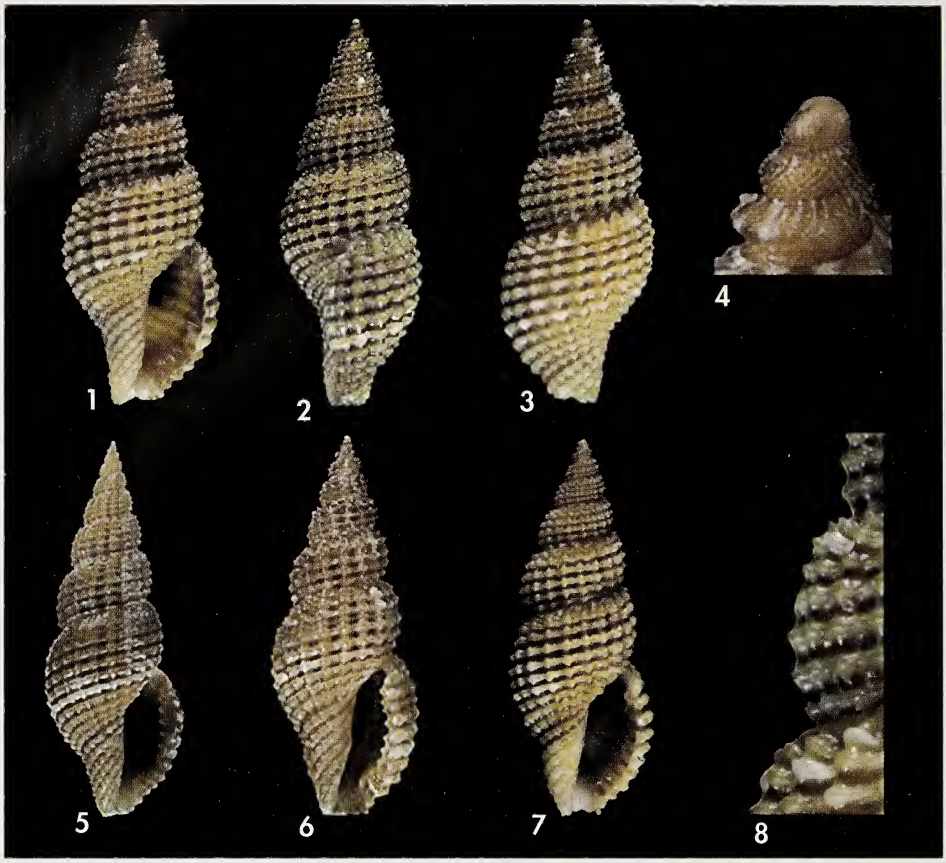
Type locality: off St. Raphael (Var), France.

Distribution: We have examined materials from the northern, central and eastern Mediterranean, and from the southern Bay of Biscay in the Atlantic. It has also been recorded in the Ría de Vigo by ROLÁN MOSQUERA (1983: 270).

Description: [Neotype] Shell fusiform, height 7.2 mm, width 2.9 mm.

Protoconch multispiral of 2.7 convex whorls, height 315 µm, width 325 µm; protoconch I of 1.2 whorls, width 230 µm, with irregularly cancellate sculpture; protoconch II of 1.5 whorls, with subsutural axial threads and a diagonally cancellate sculpture on the lower part of the spire.

Teleoconch of 5 convex whorls, with evident suture. Axial sculpture of 19 slightly opisthocline ribs, and interspaces of the same width as the ribs.



Figures 1-8. Shells of *Raphitoma lineolata* (B.D.D., 1883). 1-4, 8: neotype (MNHN, h: 7.2 mm), St. Raphael, France; 5: Ficarazzi (Palermo), Italy, h: 15.6 mm; 6: Termini Imerese (Palermo), Italy, h: 8.5 mm; 7: St. Raphael, France, h: 13 mm (photo courtesy A. Hoarau).
Figuras 1-8. Conchas de Raphitoma lineolata *(B.D.D., 1883). 1-4, 8: neotipo (MNHN, h: 7,2 mm), St. Raphael, Francia; 5: Ficarazzi (Palermo), Italy, h: 15,6 mm; 6: Termini Imerese (Palermo), Italy, h: 8,5 mm; 7: St. Raphael, Francia, h: 13 mm (foto cortesía de A. Hoarau).*

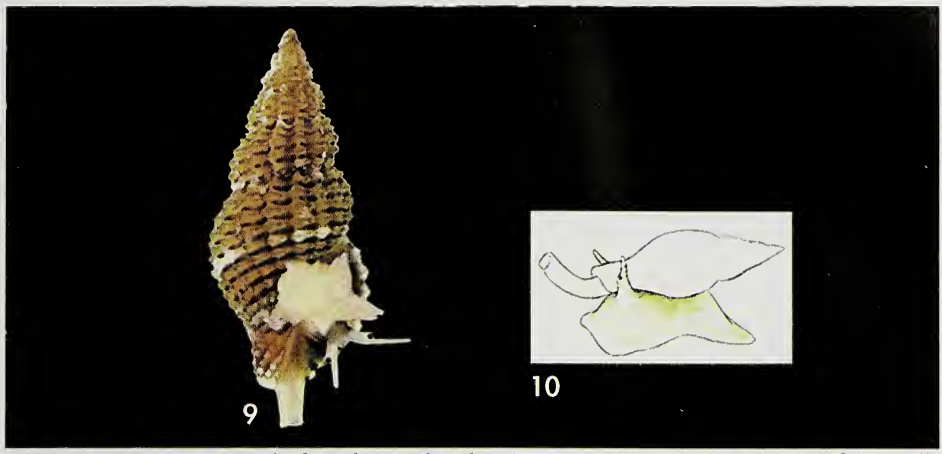
Spiral sculpture on the last whorl of 18 cordlets, of which 8 above the aperture, with interspaces wider (×1.5) than the cordlets. Cancellation rectangular, with small and elongated tubercles at the intersection of axials and spirals. Tubercles on the adapical cordlets of the first whorls narrow and spinulose. Sculpture visible in transparency throughout the internal shell wall.

Anal sinus evident, corresponding to two spiral cordlets.

Columella simple, slightly sinuous anteriorly, gently angled posteriorly. Outer lip with 11 strong inner denticles; the anteriormost, weakest, delimiting the siphonal canal and the posteriormost delimiting the anal sinus. Siphonal canal short, widely open, slightly curved.

Colour orange-tawny, with lighter cordlets and rare white tubercles. On the first teleoconch whorl two axials white. On the last whorl, the eighth abapical cordlet becoming lighter toward the peristome, with some white spots. The two axials closest to the peristome white on the central part.

Remarks: Variation in the examined material - The shell is rather slender



Figures 9, 10. Living animal of *Raphitoma lineolata* (BDD, 1883). 9: living specimen from Scilla (photo courtesy A. Vazzana); 10: sketch of a living specimen from Acitrezza, Catania (courtesy D. Scuderi).

Figuras 9, 10. Animal vivo de Raphitoma lineolata *(BDD, 1883). 9: ejemplar vivo de Scilla (foto cortesía de A. Vazzana); 10: dibujo de un ejemplar vivo de Acitrezza, Catania (cortesía de D. Scuderi).*

(h/d 2.45-2.84, mean 2.67 std 0.15), rarely exceeding 15 mm in length (7.5-15.9 mm, mean 10.3 mm std 2.2), and a maximum width of 4.4 mm (mean 3.8, std 0.7). It is possible that the dwarf forms attaining no more than 5 mm reported by Nordsieck (1977: 55) which we have never found, were in fact misidentified dwarf specimens of *Raphitoma contigua* (Monterosato, 1884), which we have observed (Pusateri et al., 2012). The teleoconch can reach 8 whorls, with 18-20 axials and 17-20 cordlets of which 7-9 above the aperture. Sometimes the axials of the last whorls are very weak. The subsutural ramp is missing, The two or three adapical spiral cordlets are finer than the others. Outer lip with 9-11 plicate inner denticles. The colour ranges from light to dark orange-tawny. The darker spiral interspaces are visible in transparency from the inner side of the aperture, on a background that is bluish only in fresh specimens.

R. lineolata has been frequently confused with *R. contigua*, from which it differs in the more slender outline (h/d >2.45 vs 2.2), the less robust shell, the lack of subsutural ramp, the narrower aperture, the generally darker colour, and a white subsutural cordlet.

D. Scuderi, kindly, provided a sketch of a living specimen from Acitrezza, Catania, describing it as "almost entirely whitish, with snow-white spots, which cover all the body: the colour becomes yellow on the upper part" (Fig. 10 (D. Scuderi, in litt., xi/2004). This description is congruent with a picture provided by A. Vazzana of a living specimen from Scilla, Calabria (Fig. 9). Templado & Llanso (1981) described the living animal of a specimen from Cabo de Palos (Murcia: found amidst *Posidonia oceanica* rhizomes) as: "animal blanco con puntinos brillantes en las zonas laterales del pie, en la parte basal de los tentaculos cefalicos y en el sifon" [white with small bright spots on the side of the foot, at the base of the cephalic tentacles and on the siphon]. The small discrepancies can fall within the geographic variation of the species or the specimens from Cabo de Palos may have been another species (e.g. we have no indication on its protoconch type).

Shells with identical teleoconchs of the *lineolata* type, but with two distinct protoconch types (multispiral vs. pau-

cispiral) are known, and we consider them as distinct species.

Bucquoy, Dautzenberg & Dollfus (1883) described *Clathurella purpurea* var. *lineolata* as following: *"Jolie variété d'une teinte rosée ornée d'une linéole brune entre chaque cordon décurrent; ces linéoles sont très apparentes sur la face interne du labre"* This short diagnosis, could in principle be referred also to *Raphitoma contigua* or *R. spadiana*, which have a similar colour pattern. However, this would change the largely prevalent usage of the name *lineolata* by all modern Authors, and raise problems of synonymy with one of Nordiecks's names. Actually, B.D.D.'s description would allow the identification of the *R. lineolata* pair of species by the reference to the darker interspaces, visible throughout the aperture, albeit they did not include any comment on the apex. The type material of *Clathurella purpurea* var. *lineolata* has neither been found at the IRSNB (Bruxelles: T. Backeljau, pers. comm.), where the Dautzenberg collection is stored, nor at MNHN (Paris: V. Héros, pers. comm.), where most of the Roussillon material described by Bucquoy *et al.* (1883) is preserved. Bucquoy *et al.* (1883: 92) reported *Clathurella purpurea* var. *lineolata* from Paulilles (Port Vendres – Roussillon South). To stabilize the use of the name *Raphitoma lineolata* we have selected as a neotype a shell with multispiral protoconch, from St. Raphael (Var), which is located ca 300 km NW of Paulilles.

Raphitoma smriglioi Pusateri & Giannuzzi-Savelli n. sp. (Figures 11-18, 21-23)

Type material: Holotype - Ognina,- 15 m, height 9.4 mm, width: 3.6 mm, MNHN. Paratypes - Ognina -15 m: A (height 9.4 mm, width: 3.9 mm, MNHN; B (height 5.9 mm, width 2.7 mm, subadult, MNHN; C, (height 4.2 mm, width 2.0 mm, coll. Smriglio). Brucoli, -20 m: D (height 8.7 mm, width 3.3 mm, coll. Pusateri).

Other material examined: Unless otherwise specified, the shells originated after sorting bioclastic sands collected between 0-40 m depth. France - St. Raphael (coll. Monterosato MCZR 16696, 3 shells); La Ciotat (coll. Monterosato MCZR 16733, 1 shell). Croatia – Unprecised locality (coll. Delemarre, 1 shell). Italy - Napoli, Campania (coll. Monterosato MCZR 16877, 1 shell); Capri Is., (coll. Monterosato MCZR 16733, 1 shell; coll. Coen HUJ, sub nomine ms. "Philbertia purpurea mitis M (ms) typus, Capri!" handwritten by Coen, 1 shell). Porto Cesareo (LE), Apulia (coll. Micali, 1 shell); Marina di Ugento, Apulia (coll. Macrì, 7 shells); Scilla (Reggio Calabria), Calabria (coll. Vazzana, 1 shell). Brucoli (Siracusa), Sicily (coll. Pusateri, 1 shells + 2 shells subadult); Gulf of Carini, Sicily (coll. Palmeri, 1 shell); Ognina (Siracusa), Sicily (coll. Pusateri, 12 shells subadult); Cannizzaro (CT), Sicily (coll. Micali, 1 shell). Greece – Limnos Is. (coll. Sercia, 1 shell). Cyprus – off Larnaka, - 42 m (coll. Bartolini). Turkey – Bozcaada Is. (coll. Pusateri, 1 shell). Adana (coll. Can Geyran Seashell Center, 1 shell).

Type locality: Ognina (Siracusa), 36°58'N, 15°15'E.

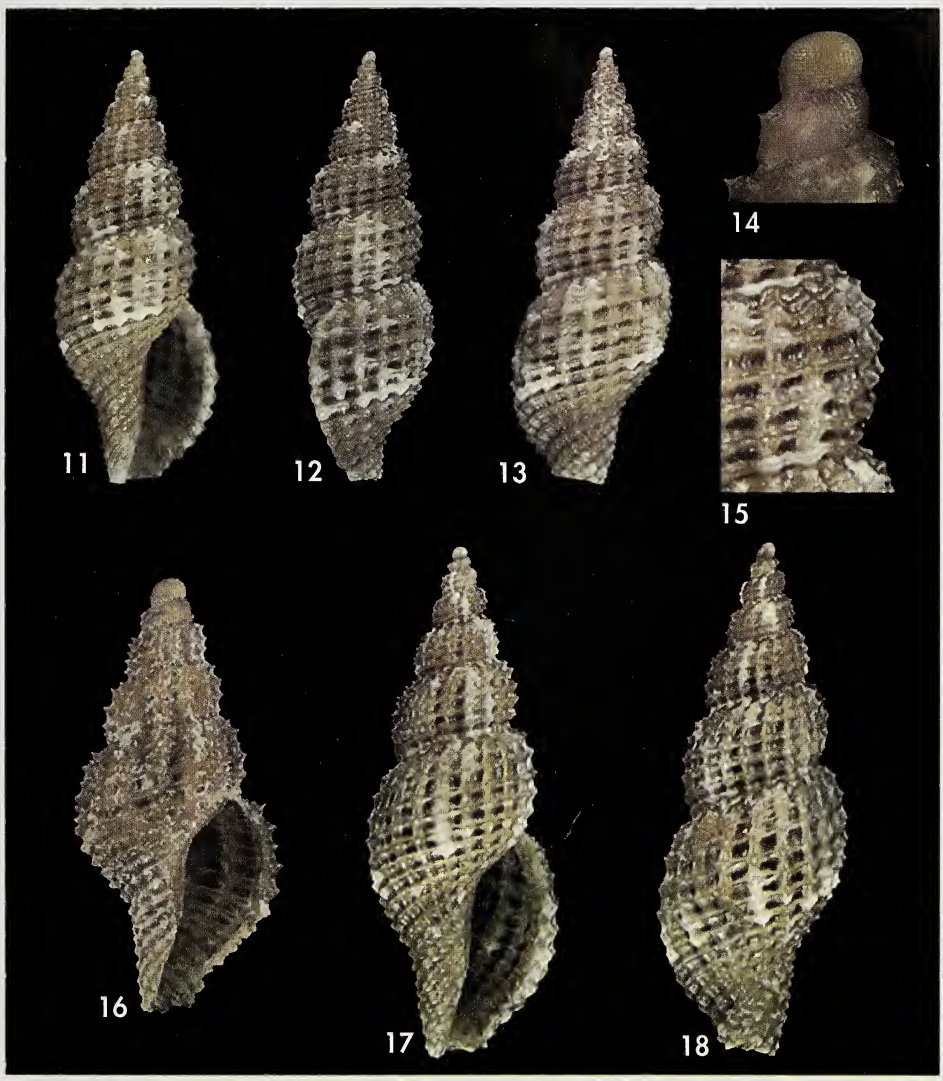
Etymology: after our dear friend Carlo Smriglio, in homage to his contribution to the knowledge of the northeastern Atlantic malacofauna.

Distribution: known so far from the central and eastern Mediterranean Sea, where it is relatively uncommon.

Description: Shell fusiform, height 9.4 mm, width 3.5 mm. Protoconch paucispiral of 1.5 convex whorls, height 405 µm, width 400 µm; sculpture irregularly cancellate.

Teleoconch of 7 convex whorls, with evident suture. Axial sculpture of 18 orthocline ribs, and interspaces slightly wider than the ribs. Spiral sculpture on the last whorl of 18 cordlets, of which 7 above the aperture, with interspaces wider (×1.8) than the cordlets. The first subsutural spiral cordlet finer than the others. Cancellation rectangular, with small and elongated tubercles at the intersection of axials and spirals. Sculpture visible in transparency throughout the internal shell wall.

Subsutural ramp absent. Anal sinus evident, corresponding to two spiral cordlets.

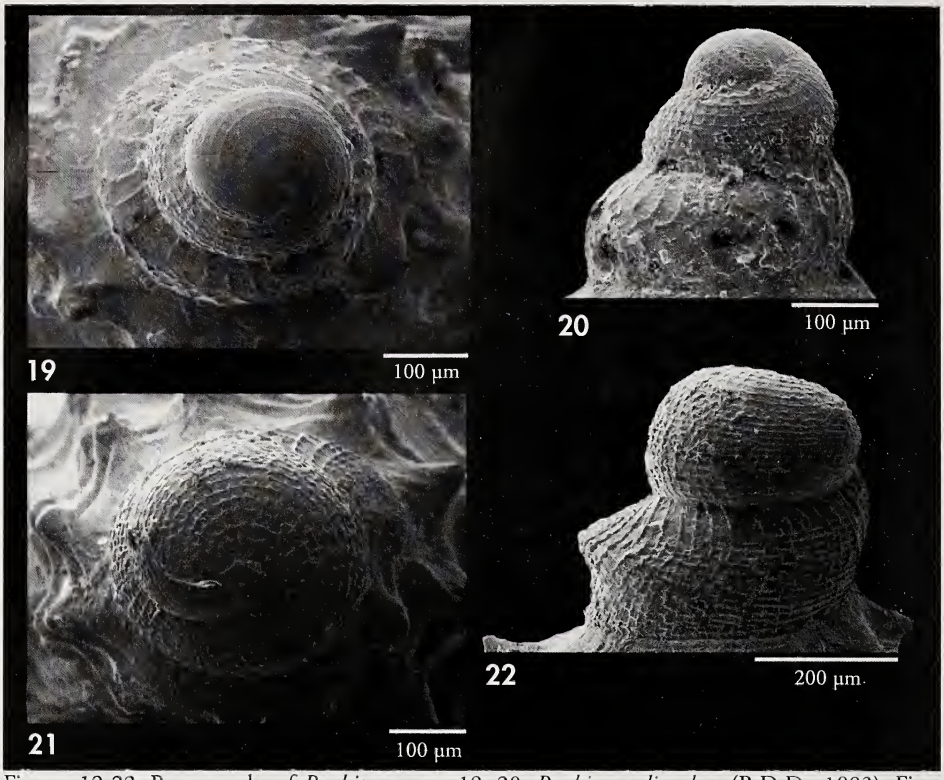


Figures 11-18. Shells of *Raphitoma smriglioi* n. sp. 11-15: holotype, Ognina (Siracusa), Italy (MNHN, h: 9.4 mm); 16: paratype B, Ognina (Siracusa), Italy (MNHN, h: 5.9 mm); 17, 18: paratype D, Brucoli (Siracusa), Italy (coll. Pusateri, h: 8.7 mm).
Figuras 11-18. Conchas of Raphitoma smriglioi *n. sp. 11-15: holotipo, Ognina (Siracusa), Italia (MNHN, h: 9,4 mm); 16: paratipo B, Ognina (Siracusa), Italia (MNHN, h: 5,9 mm); 17, 18: paratipo D, Brucoli (Siracusa), Italia (coll. Pusateri, h: 8,7 mm).*

Columella simple, sinuous anteriorly, gently angled posteriorly. Outer lip with 10 strong inner denticles; the anteriormost delimiting the siphonal canal and the posteriormost delimiting the anal sinus. Siphonal canal short, widely open.

Colour orange-tawny, with lighter cordlets and sparse white spots, and short white segments of the suprasutural cordlet.

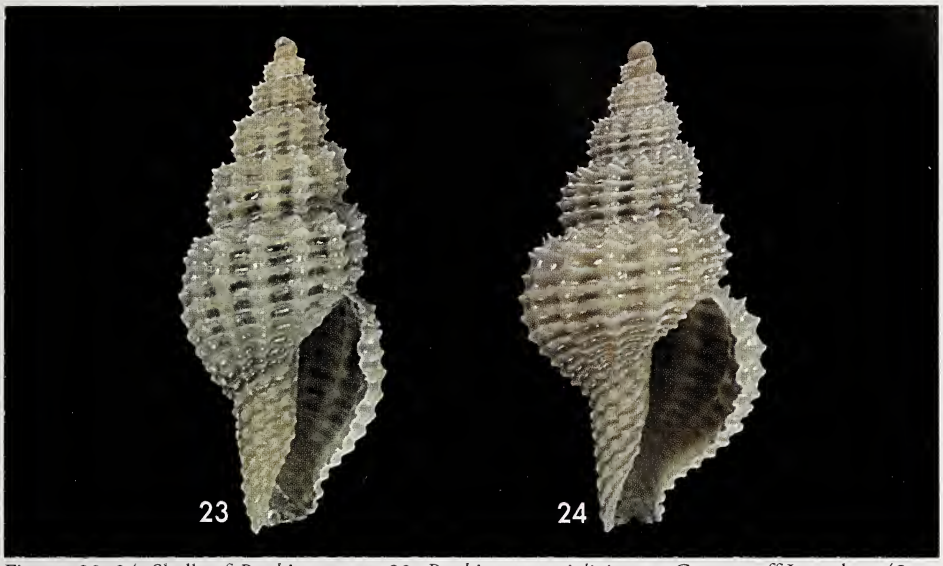
Remarks: Variation in the examined material - The shell is slender (h/d 2.26-2.64, mean 2.49, std 0.12), 5.9-11.1 mm in



Figures 19-22. Protoconchs of *Raphitoma* spp. 19, 20: *Raphitoma lineolata* (B.D.D., 1883), Ficarazzi (Palermo), Italy; 21, 22: *Raphitoma smriglioi* n. sp. Ognina (Siracusa), Italy.
Figures 19-22. Protoconchas de Raphitoma *spp. 19, 20:* Raphitoma lineolata *(B.D.D., 1883), Ficarazzi (Palermo), Italia; 21, 22:* Raphitoma smriglioi *n. sp. Ognina (Siracusa), Italia.*

Table I. Provisional list of pairs of sibling species of the genus *Raphitoma*. (1) Nomen novum pro *R. brevis* Nordsieck, 1977, non Seguenza, 1880; (2) nomen novum pro *Clathurella cylindrica* Locard & Caziot, 1899 non Pease, 1860.
Table I. Lista provisional de parejas de especies gemelas del género Raphitoma. *(1) Nomen novum pro R. brevis Nordsieck, 1977, non Seguenza, 1880; (2) nomen novum pro* Clathurella cylindrica *Locard & Caziot, 1899 non Pease, 1860.*

multispiral protoconch	paucispiral protoconch
R. bicolor (Risso, 1826)	*R. farolita* Nordsieck, 1977
R. contigua Monterosato, 1884	*R. spadiana* Pusateri & Giannuzzi-Savelli, 2012
R. sp. (probably undescribed)	*R. papillosa* (Pallary, 1904)
R. lineolata (B.D.D., 1883)	*R. smriglioi* n. sp.
R. laviae (Philippi, 1836)	*R.* sp. (probably undescribed)
R. brunneofasciata nom. nov. (1)	*R. syrtaensis* Nordsieck, 1977
R. radula (Monterosato, 1884)	*R. neapolitana* Nordsieck, 1977
R. oblonga (Jeffreys, 1867)	*R. alleryana* (Sulliotti, 1889)
R. echinata (Brocchi, 1814)	*R. nivea* (Marshall in Sykes, 1906)
R. sp. (probably undescribed)	*R.* sp. (probably undescribed)
R. locardi nom nov. (2)	*R. philberti* (Michaud, 1829)



Figures 23, 24. Shells of *Raphitoma* spp. 23: *Raphitoma smriglioi* n.sp., Cyprus, off Larnaka, -42 m, h: 7.0 mm; 24: *Raphitoma spadiana* Pusateri & Giannuzzi-Savelli, 2012, same locality, h: 6.5 mm. *Figuras 23, 24. Conchas de* Raphitoma *spp. 23:* Raphitoma smriglioi *n.sp., Chipre, frente a Larnaka, -42 m, h: 7,0 mm; 24:* Raphitoma spadiana *Pusateri & Giannuzzi-Savelli, 2012, misma localidad, h: 6,5 mm.*

length (mean 8.1 mm, std 1.7), and 2.6-4.2 mm in width (mean 3.2 mm, std 0.5). The colour ranges from orange-tawny to very light tawny.

R. smriglioi differs from *R. lineolata*, in its paucispiral protoconch, indicating a non-planktotrophic development (vs. a planktotrophic development of *R. lineolata*). *R. smriglioi* differs from *R. contigua* in its paucispiral protoconch, the more slender shell (h/d > 2.2, mean 2.63 vs. 2.2) and the lack of a subsutural ramp. *R. smriglioi* is also similar to *R. spadiana* (Fig. 24: the sister of *R. contigua*) in the general shell features but differs in the lack of a subsutural ramp and in the protoconch, which is slightly smaller and more slender in *smriglioi* (405 µm x 400 µm [h/d 1.06] vs. 425 µm x 450 µm in *spadiana* [h/d 0.94]).

While *R. lineolata* ranges throughout the entire Mediterranean Sea and extends into the neighbouring Atlantic, the known range of *R. smriglioi* includes only the central and eastern Mediterranean Sea, where it is also less common than *R. lineolata*.

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Distribución y censo actualizado de la lapa ferrugínea (*Patella ferruginea* Gmelin, 1791) en el litoral de Melilla (Mediterráneo suroccidental)

Distribution and updated census of the ferrugineous limpet (*Patella ferruginea* Gmelin, 1791) in the littoral of Melilla (SW Mediterranean)

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RESUMEN

Se evalúa la población de la lapa ferrugínea (*Patella ferruginea*), una especie en peligro de extinción, en todo el litoral de la Ciudad Autónoma de Melilla, mediante muestreos realizados entre marzo y junio de 2010. Además, se realizaron censos detallados en ocho transectos distribuidos a lo largo de su línea de costa. Los resultados permiten estimar una población total de 32.821 ejemplares adultos (de talla superior a 30 mm de diámetro máximo de la concha). La población muestra una distribución por tallas/edades bien estructurada, con un amplio rango de tallas, desde juveniles a ejemplares grandes, siendo escasos los ejemplares de talla superior a 90 mm. *Patella ferruginea* se distribuye en Melilla tanto en la costa rocosa natural como en las numerosas estructuras artificiales que constituyen más de la mitad de su litoral. Destaca su abundancia en la escollera exterior del puerto, donde se concentra el 68,1% de toda la población estimada. La densidad media de adultos para el conjunto del litoral (excluyendo las zonas de costa con hábitats inadecuados para la especie) es de 2,8 adultos/m y el valor máximo registrado en un transecto es de 66,5 adultos/m. Aparte de las zonas con sustrato inadecuado (playas), *P. ferruginea* está ausente en el 44,0% del litoral de Melilla, correspondiente al interior de las áreas portuarias y a zonas donde se han realizado recientemente obras. La comparación entre los datos de 2010 y 2006 indica que las obras costeras realizadas durante esos cuatro años habrían supuesto la desaparición de unos 1.900 ejemplares adultos de *P. ferruginea*, en zonas en las que en la actualidad apenas parece haber comenzado la recolonización de la especie sobre los nuevos sustratos instalados. A pesar de esa mortalidad, los cálculos globales actuales de la población suponen un incremento del 69,2% respecto a la estimación realizada en 2006, debido sobre todo al estudio más detallado de algunas zonas de su litoral, en particular la escollera exterior del puerto. Los resultados destacan que el litoral de Melilla es uno de los escasos lugares en los que todavía existe una importante población de esta lapa amenazada, por lo que debe considerarse un área crítica cuya correcta gestión es esencial para la supervivencia y la recuperación de la especie.

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ABSTRACT

The population of the ferrugineous limpet (*Patella ferruginea*), a species in risk of extinction, is evaluated in the whole littoral of the Autonomous City of Melilla (Spain) by sampling done between March and June, 2010. Moreover, detailed censuses were performed in eight transects distributed along the coastline. Results allow to estimate a total population of 32,821 adult specimens (shell maximum diameter larger than 30 mm). The population shows a well structured size/age distribution, with a wide range of sizes from young to large individuals, but specimens larger than 90 mm are scarce. *Patella ferruginea* is distributed in Melilla both on the natural rocky shores and on the numerous artificial structures which constitute more than a half of the littoral. It should be pointed out its abundance on the external breakwater of the Melilla port, where is concentrated the 68.1% of the estimated population. The average density of adults for the whole littoral (excluding coastal zones with unsuitable habitats for the species) is 2.8 adults/m, with a maximum value of 66.5 adults/m in a transect. Excepting zones with unsuitable substrate (beaches), *P. ferruginea* is lacking in the 44.0% of the littoral of Melilla, which corresponds to the inner port areas and the littoral stretches where coastal works have been done recently. Comparison between data of 2010 and 2006 shows that coastal works done during those four years may have meant the disappearance of about 1,900 adult individuals of *P. ferruginea*, in zones where recolonization on the new installed substrates seems to have hardly begun nowadays. Despite of that mortality, the present global estimation of the population means an increase of 69.2% with regard to the 2006 estimation, mainly due to the more detailed study of some zones, specially the external breakwater of the port. The results pointed out that the littoral of Melilla is one of the few places in which there is still an important population of this endangered limpet, and therefore it should be considered a critical area whose right management is essential for the survival and recovery of the species.

INTRODUCCIÓN

La lapa ferrugínea (*Patella ferruginea* Gmelin, 1791) es un gasterópodo marino endémico del Mediterráneo occidental considerado como uno de los invertebrados más amenazados de esta región geográfica. Es una lapa de gran tamaño, cuya concha puede superar los 100 mm de diámetro máximo y que habita una zona marina muy accesible, el piso mesolitoral superior (Templado, 2001). Es una especie hermafrodita para la que se había asumido la existencia de protandria (Frenkiel, 1975; Laborel-Deguen y Laborel, 1991b; Guerra-García, Corzo, Espinosa y García-Gómez, 2004; Templado, Calvo, Garvía, Luque, Maldonado y Mozo, 2004; Espinosa, Guerra-García, Fa y García-Gómez, 2006). El cambio de sexo fue descrito por Espinosa, Rivera-Ingraham y García-Gómez (2009) y se ha observado que puede tener lugar en ambos sentidos (Guallart, Calvo y Cabezas, 2010). Se supone que es una especie de crecimiento lento, para la que se ha sugerido una longevidad superior a 30 años (Espinosa, González, Maestre, Fa, Guerra-García y García-Gómez, 2008). Además, se ha señalado para esta especie una fecundidad baja y una fase planctónica de corta duración que limitaría mucho su capacidad de dispersión larvaria (Laborel-Deguen y Laborel, 1991b; Guallart, Calvo, Acevedo y Peña, 2010).

Su distribución geográfica está bien datada desde antiguo, debido a los numerosos restos que se conservan en concheros de diversos yacimientos neolíticos. Hasta finales del siglo XIX se distribuía por la mayor parte de la cuenca occidental del Mediterráneo; sin embargo, a lo largo del siglo XX ha sufrido una importante regresión (Laborel-Deguen y Laborel, 1991a; Porcheddu y Milella, 1991; Templado *et al.*, 2004).

Actualmente, esta especie se considera extinta en la mayor parte de las

costas continentales europeas. Su área de distribución se halla restringida a algunas zonas de Córcega y de Cerdeña, algunos pequeños archipiélagos en las proximidades de estas dos islas y la isla de Pantellaria, en el canal de Sicilia. Se encuentra también en la costa italiana peninsular en algunas localidades aisladas del litoral toscano, y en el sur de la península Ibérica. Sin embargo, las principales poblaciones se encuentran en las costas mediterráneas del norte de África (FRENKIEL, 1975; PORCHEDDU Y MILELLA, 1991; BOUMAZA Y SEMROUD, 2001; TEMPLADO, 2001; ESPINOSA, 2009; ARROYO, MORENO, BARRAJÓN, DE LA LINDE, REMÓN, DE LA ROSA, FERNÁNDEZ-CASADO, GÓMEZ, RUIZ-GIRÁLDEZ, VIVAS Y FERNÁNDEZ, 2011; RIVERA-INGRAHAM, ESPINOSA Y GARCÍA-GÓMEZ, 2011a).

La regresión de esta especie a lo largo de toda su área de distribución se atribuye a la presión humana, sobre todo debido a la recolección para su consumo, su uso como cebo o simplemente para coleccionismo. Tanto la accesibilidad de su hábitat como su gran tamaño habrían contribuido a su declive (TEMPLADO, 2001; PARACUELLOS, NEVADO, MORENO, GIMÉNEZ Y ALESINA, 2003; MORENO Y ARROYO, 2008; ESPINOSA, MAESTRE Y GARCÍA-GÓMEZ, 2009). Las obras en el litoral, la destrucción de su hábitat natural y la contaminación marina (vertidos de aceites, petróleo y otras sustancias flotantes) se consideran también factores importantes en la regresión de la especie (RAMOS, 1998; TEMPLADO, 2001; ESPINOSA, GUERRA-GARCÍA Y GARCÍA-GÓMEZ, 2007; MORENO Y ARROYO, 2008).

El estado de regresión de *Patella ferruginea* impulsó su inclusión en diversas figuras de protección de la legislación europea (Anexo II del Convenio de Berna, Anexo II del Convenio de Barcelona, Anexo IV de la Directiva de Hábitats). Desde 1999 está incluida en el Catálogo Español de Especies Amenazadas, en su máxima categoría de protección, "en peligro de extinción". En este sentido, la Ley 42/2007 del Patrimonio Natural y de la Biodiversidad (artículo 56) establece que la inclusión de una especie en la categoría "en peligro de extinción" conllevará, en un plazo máximo de tres años, la adopción de un plan de recuperación para asegurar su conservación, cuya elaboración y aprobación corresponde a las comunidades autónomas y ciudades con estatuto de Autonomía. El artículo 57 de la mencionada Ley establece asimismo que, para las especies amenazadas presentes en más de una comunidad autónoma, como es el caso de *Patella ferruginea*, deben aprobarse estrategias de conservación, que constituirán el marco orientativo de los planes de recuperación, e incluirán al menos un diagnóstico de la situación y de las principales amenazas para las especies, y las acciones a emprender para su recuperación. En consecuencia, en 2008 se aprobó la "Estrategia para la conservación de la lapa ferrugínea (*Patella ferruginea*) en España" (MMAMRM, 2008), que representa el primer esfuerzo dirigido a establecer actuaciones concretas para la conservación de un invertebrado marino en España. En la Estrategia se recomienda el control anual de las poblaciones reproductoras, realizando un censo exhaustivo al menos cada cuatro años. Sin embargo, hasta el momento no se ha aprobado ningún plan de recuperación en las comunidades o ciudades autónomas en las que se encuentra la especie (Andalucía, Ceuta, Melilla y Murcia).

El Real Decreto 139/2011 para el desarrollo del Listado de Especies Silvestres en Régimen de Protección Especial y del Catálogo Español de Especies Amenazadas, establece en su artículo 9 que las especies incluidas en el Listado serán objeto de un seguimiento por parte de las comunidades autónomas o ciudades con estatuto de autonomía en cuyo territorio se localicen dichas especies, con el fin de realizar una evaluación periódica de su estado de conservación. Este Real Decreto establece además, que, para las especies incluidas en el Catálogo, y a no ser que la estrategia de la especie señale una periodicidad distinta, las evaluaciones se efectuarán como máximo cada tres años para las especies «en peligro de extinción».

Un primer intento de sintetizar la información disponible sobre el estado reciente de las poblaciones de *Patella ferruginea* en las costas españolas se realizó entre 2005 y 2007 en el marco de la elaboración de la Estrategia Nacional para la Conservación de la lapa ferrugínea (MMAMRM, 2008). La evaluación detallada del estado de conservación de cada una las poblaciones actuales de esta especie debía permitir, por una parte, conocer el estado de conservación de la especie en su conjunto, determinar su potencial reproductor en cada zona, evaluar la interconexión entre las diferentes poblaciones y analizar las posibles amenazas que puedan existir en cada una de éstas y que comprometan su viabilidad futura. Este conocimiento es fundamental a la hora de elaborar los planes de recuperación de la especie.

En esta primera síntesis (MMAMRM, 2008) se indicaba que la distribución en la costa peninsular española se restringía a Andalucía, en cuyos 1.100 km de litoral se localizarían poco más de 700 ejemplares. A estos habría que sumar los 364 ejemplares censados en 2007 en la isla de Alborán. Las principales poblaciones españolas se localizarían en los territorios del norte de África: Ceuta, con más de 30.000 ejemplares, Melilla, con unos 23.000 ejemplares y, sobre todo, las islas Chafarinas, con una población que podría superar los 60.000 ejemplares.

Estos primeros datos se han actualizado con nuevos censos y trabajos de seguimiento, sobre todo en la costa peninsular de Andalucía y en la isla de Alborán (Moreno y Arroyo, 2008; Arroyo *et al.*, 2011) y en Ceuta (Rivera-Ingraham, Espinosa y García-Gómez, 2011a). Recientemente Espinosa *et al.* (2009) ampliaron hacia el norte la distribución de la especie en España con la cita de dos ejemplares en las islas Hormigas, frente a cabo de Palos. Guallart, Acevedo y Calvo (2012) han señalado además su presencia en otro enclave español en el norte de África, el peñón de Vélez de la Gomera.

Las primeras estimaciones de la densidad y la abundancia de *Patella ferruginea* y de su distribución en el litoral de la Ciudad Autónoma de Melilla fueron realizadas por González-García, Bueno del Campo, García Piña y Bazaïri (2006) y Guallart, Templado, Calvo, Cabezas, Acevedo, Machordom y Luque (2006), de manera independiente y casi simultánea. La estimación de la población total de Melilla proporcionó unos resultados similares: entre 18.000 y 20.000 ejemplares en total según González-García *et al.* (2006) y unos 19.400 ejemplares adultos según Guallart *et al.* (2006). En ambos trabajos se destacaban las dificultades para hacer un cálculo preciso de la población en el lugar que presentaba mayor abundancia, la parte exterior de la escollera del puerto de Melilla, que presenta un trazado del litoral complejo formado por bloques dispuestos de manera muy irregular.

El presente trabajo se enmarca dentro de las líneas de actuación señaladas anteriormente y tiene como objetivo realizar un censo actualizado de la población de *Patella ferruginea* en el litoral de Melilla y una revisión de su distribución y abundancia, mediante un estudio más detallado que los realizados anteriormente. En particular, se plantea aplicar una metodología más adecuada para estimar la población de la escollera exterior del puerto.

Durante los últimos años se han realizado diversas obras de importancia en el litoral de la Ciudad Autónoma, algunas de las cuales han cambiado significativamente el perfil de la línea de costa, y que se detallan al hablar del área de estudio. Este trabajo tiene, además, el objetivo adicional de evaluar el impacto de dichas obras en la población de *Patella ferruginea*.

MATERIAL Y MÉTODOS

Área de estudio

La Ciudad Autónoma de Melilla se halla en la costa norteafricana, en el SE del mar de Alborán. Ocupa una superficie aproximada de 12,5 km², y tiene un litoral, en línea recta, de unos 5,5 km (Figura 1).

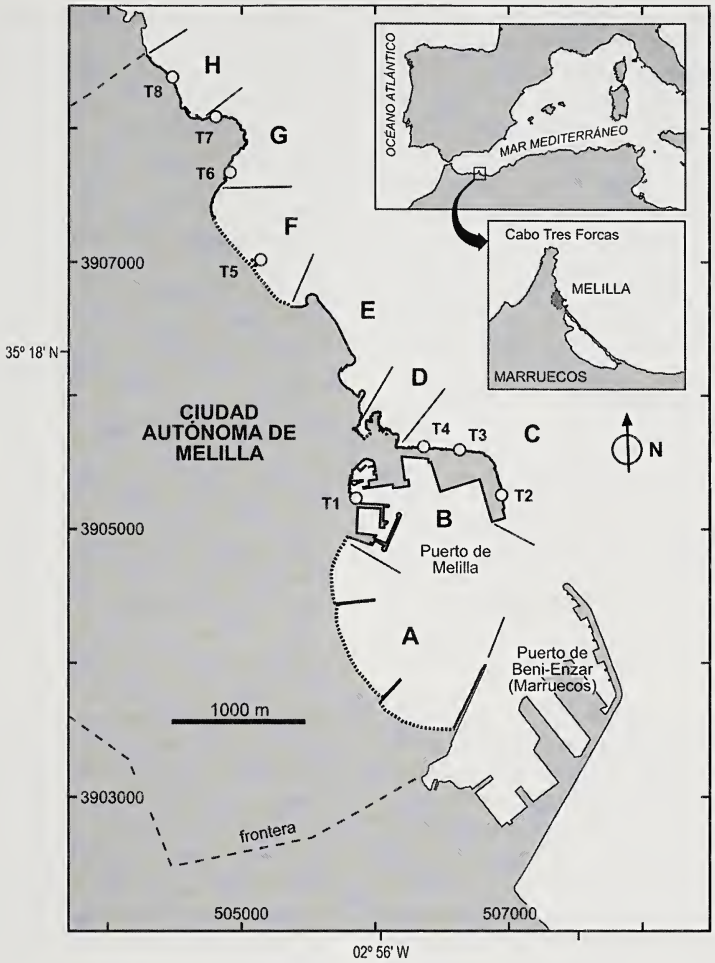


Figura 1. Localización geográfica del área de estudio, la Ciudad Autónoma de Melilla. La línea de costa se basa en el trazado representado en el PGMOCAM (2009). Se indican los 8 sectores (A-H) en que se dividió la línea de costa con fines descriptivos y los 8 transectos (T1-T8) en los que se realizaron censos de ejemplares (ver texto). Se destacan con línea discontinua de puntos las playas de arena (nótese que, debido a la escala, no quedan bien representadas las pequeñas playas de arena localizadas en el sector D, bajo las cuevas del Conventico y en la ensenada de los Galápagos). Coordenadas UTM (huso 30) y geográficas en datum WGS84.

Figure 1. Location of the studied area, the Autonomic City of Melilla. The coastline is based on the map from PGMOCAM (2009). The sectors (A-H) in which the coast was divided with descriptive aims and the transects (T1-T8) in which census of specimens were performed are indicated (see text). Sand beaches are pointed out with discontinuous point lines (it should be noted that due to scale, small beaches located in sector D, under Conventico caves and Galápagos inlet are not well distinguished). UTM (zone 30) and geographic (datum WGS84) coordinates.

El litoral de Melilla, incluyendo tanto las prominencias rocosas y calas naturales como las diferentes estructuras artificiales construidas, tiene una longitud total de 16.298 m, según los cálculos realizados a partir de la cartografía a escala 1:10.000 del Plan General Municipal de Ordenación de la Ciudad

Tabla I. Caracterización de la línea de costa en la Ciudad Autónoma de Melilla en el momento de la realización de los muestreos (marzo-junio 2010). Se indica la longitud de costa (y el porcentaje respecto al total) correspondiente a playas (sustrato inadecuado para *P. ferruginea*) y sustratos duros (costa rocosa), tanto de origen natural como artificial. Se considera como costa alterada recientemente aquella en la que se han realizado obras que han supuesto la desaparición de los ejemplares previamente censados. Se distinguen en este caso las obras que tuvieron lugar durante los 2 años y entre los 2 y 4 años previos a los muestreos (ver texto).

Table I. Coastline features of the Autonomic City of Melilla at the time of sampling (march-june 2010). It is indicated the coast length (and percentage regarding total length) of beaches (unsuitable substrate for Patella ferruginea*) and hard bottoms (rocky coast), both of natural and artificial origin. It is considered as recently altered coast that in which recent coastal works led to mortality of specimens previously censed, distinguishing between coastal works done two years and 2-4 years before samplings (see text).*

Tipología actual de la línea de costa	Longitud		Costa alterada recientemente			
			< 2 años		2-4 años	
	m	% del total	m	% tipología	m	% tipología
Playas	3.307	20,3	282	8,5	-	-
Sustrato duro artificial	9.496	58,3	1.177	12,4	-	-
Sustrato duro natural	3.495	21,4	23	0,7	175	5,0
Total	16.298	100	1.482	9,1	175	1,1

Autónoma de Melilla en 2009 (PGMOCAM, 2009). De ellos (Tabla I), un 20,3% corresponde a sustratos blandos, un tipo de hábitat inadecuado para *P. ferruginea*. El resto del litoral (79,7%), formado por sustratos duros, está constituido en su mayor parte por construcciones artificiales, incluyendo las estructuras portuarias, tanto las escolleras de abrigo como las paredes interiores, pantalanes, etc. Además de estas estructuras, hay que sumar diversas escolleras dispuestas perpendicularmente a la costa y otras obras recientes con las que se ha ganado terreno al mar. Las estructuras de sustrato duro de origen artificial suponen más de la mitad (58,3%) del total del litoral de la ciudad, mientras que la costa rocosa natural representa el restante 21,4%.

En este trabajo se ha considerado como litoral "natural" aquellas zonas en las que pueden haberse producido importantes actuaciones humanas, que sin duda han afectado a la comunidades litorales preexistentes, pero que han cambiado muy poco la línea de costa. Así, se han considerado "naturales" algunas zonas de acumulación de bloques artificiales en el sector H que, transcurrido un tiempo, han adquirido características bióticas similares a los bloques de erosión del acantilado próximo.

Con fines descriptivos, se ha dividido el litoral de la Ciudad Autónoma en 8 sectores (Figura 1), cuya longitud se ha calculado a partir de la cartografía del PGMOCAM (2009).

El sector A ("Paseo marítimo") comprende una zona dominada por playas, de casi 2 km de longitud, que están divididas en tres tramos por espigones artificiales de rocas cuya función principal es regular la distribución de la arena. El espigón más meridional representa, además, la división con el puerto de Beni-Enzar, es decir, la frontera con Marruecos. Este sector está enclavado en una zona portuaria, semiencerrada por las escolleras exteriores de ambos puertos (Melilla y Beni-Enzar), por lo que los niveles de eutrofización del agua suelen ser moderados o incluso altos (obs. pers.). A pesar de ello, estas playas constituyen la principal zona de baño de la ciudad. Los espigones citados son zonas muy frecuentadas por pescadores deportivos, que

podrían actuar sobre los ejemplares de *P. ferruginea*.

El sector B ("Puerto interior") comprende todas las estructuras del interior del puerto de Melilla, tanto del puerto comercial como de los dos puertos deportivos. El 100% de la línea de costa está formado por estructuras artificiales con una cierta diversidad de tipologías: paredes verticales de hormigón (zona de atraque del puerto comercial, algunas zonas de los puertos deportivos), paredes verticales construidas con roca de canteras locales (paredes del antiguo descargadero de mineral), espigones formados por el acúmulo de bloques principalmente calcáreos o de granito (algunas zonas del interior de los puertos deportivos) o escolleras formadas por tetrápodos de hormigón de superficie lisa (escollera exterior del puerto deportivo Puerto Noray).

El sector C ("Puerto exterior") es la zona más compleja en cuanto al estudio de *P. ferruginea* en el litoral de Melilla. Está formado en su mayor parte por la superposición de bloques de hormigón ortoédricos de varios metros de arista, dispuestos de manera irregular (Figura 2A, B) que constituyen la escollera exterior del dique del puerto comercial. La mayor parte del recorrido de la escollera corresponde a bloques instalados en la primera prolongación del dique exterior del puerto realizada en la década de 1920, con aportes adicionales de bloques para las reparaciones del dique en décadas posteriores (SERRANO DARDE, 2009). Tanto por las características de construcción como por el tiempo transcurrido desde su instalación pueden catalogarse como bloques erosionados de hormigón, en cuya superficie destaca la presencia de bloques medianos, clastos y cantos rodados, procedentes de canteras locales (Figura 2B). Por otra parte, en los últimos años del siglo XX la escollera del puerto se prolongó hacia el SE unos 175 m, utilizándose en parte bloques de hormigón constituidos por áridos de grano fino, que presentaban durante los muestreos una superficie mucho más lisa. A lo largo de este trabajo se cita a los primeros como bloques de "hormigón erosionado de superficie irregular (HESI)" y a los segundos como bloques de "hormigón reciente de superficie lisa (HRSL)". En esa ampliación, finalizada en 2000, el extremo final (unos 65 m) y la bocana se construyeron como un muro vertical de hormigón, y se consolidó además parte de la escollera, aportando en algunas zonas nuevos bloques HRSL, sobre todo en el extremo NE, donde su trazado cambia de dirección (Figura 2A, B) (JIMÉNEZ ABELLÁN, 2009).

El sector D ("Melilla la vieja") corresponde al promontorio de la ciudad antigua, y es uno de los escasos sectores en los que se conserva inalterado el perfil de la costa rocosa natural de la zona. Está constituida principalmente por acantilados medios y altos tipo "plunging"; asimismo, se encuentran dos pequeñas playas encajadas en el acantilado, la de las cuevas del Conventico y la de la ensenada de los Galápagos.

El sector E ("El Morrillo") es la zona donde mayores transformaciones se han realizado durante los dos años previos a este estudio. Actualmente, sólo incluye una pequeña zona de litoral natural, correspondiente a la parte NW de la ensenada de los Galápagos, constituida por acantilados bajos casi verticales. A partir de ahí se localizan las zonas de actuaciones más recientes, que incluyen un pequeña escollera de rocas, una corta playa artificial y la obra más importante, realizada entre 2007 y 2008 en la punta de El Morrillo, para estabilizar una escombrera-vertedero preexistente. En esa obra se construyó una escollera paralela a la línea de costa, formada por bloques subcúbicos de hormigón de árido fino (semejante a los HRSL) a lo largo de algo más de 1 km, y se rellenó con nuevo material, ganando una superficie aproximada de 11,5 ha de terreno al mar (Figura 2C). Esta construcción supuso la alteración de aproximadamente 800 m de costa natural formada hasta aquel momento por acantilados y pequeñas playas encajadas.

El sector F ("Horcas Coloradas") comprende al litoral situado en la base

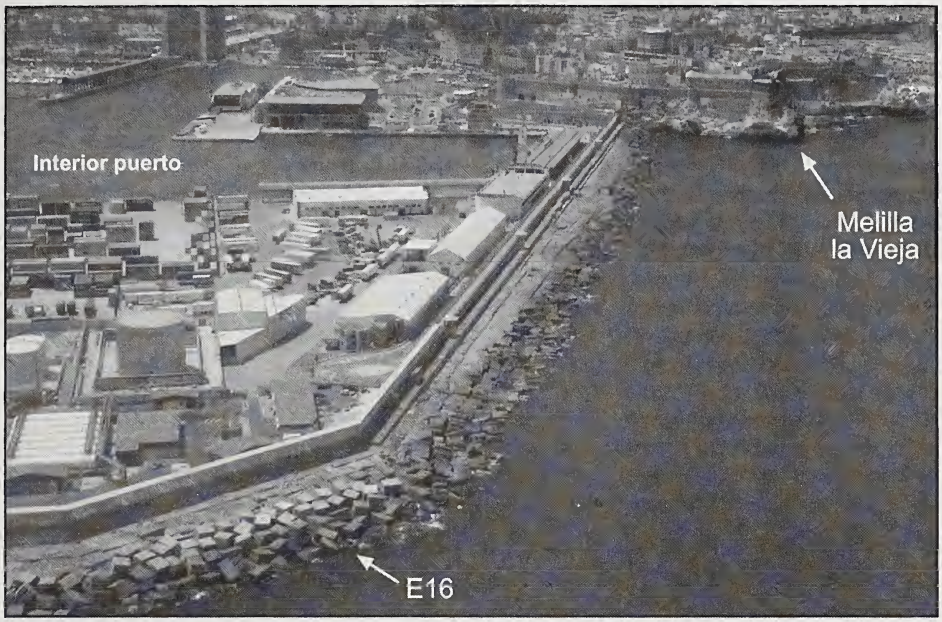
del acantilado de Horcas Coloradas, que presenta la playa natural de mayor longitud de Melilla, unos 890 m. Este sector incluye asimismo en su extremo norte una pequeña prominencia rocosa y una zona ocupada por bloques consolidados de tamaño mediano y grande. A unos 50 m frente a la playa, destacan dos pequeños islotes de unos 7 m de diámetro cada uno, en los cuales se realizó un censo completo de ejemplares.

El sector G ("Rostrogordo") comprende una zona de acantilados bajos, en su mayor parte verticales y con un *"trottoir"* litoral de algas calcáreas bien desarrollado, aunque también hay algunos lugares con plataformas rocosas subhorizontales. Su mitad sur es una zona muy frecuentada en verano por pescadores deportivos y bañistas. En esta zona se localiza el vertido de agua hipersalina de la planta desalinizadora de la ciudad, que empezó a funcionar en 2007. Este vertido cae en forma de cascada de unos 10 m de altura, cubriendo la pared del acantilado en unos 22 m de su recorrido (Figura 2D).

Por último, el litoral del sector H ("LIC Acantilados Aguadú") corresponde a una zona protegida, declarada en julio de 2006 como Lugar de Importancia Comunitaria (LIC ES6320001 Marítimo Terrestre de los Acantilados de Aguadú). Está constituido mayoritariamente por una zona de acumulación de bloques medios y grandes. Buena parte de ellos proceden de la erosión natural del acantilado colindante y están en su mayoría consolidados. Una parte de estos bloques, sin embargo, corresponden al aporte de materiales rocosos realizado entre 2005 y 2006 para la construcción de una pista que permitiese el acceso de vehículos para el control de la frontera. Además de otros aportes, en esta obra se colocaron en un determi-

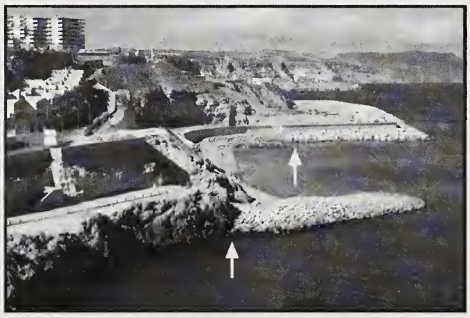
(Página derecha) Figura 2. Fotografías del litoral de Melilla. A: vista aérea de la escollera exterior del puerto, mostrando la disposición irregular de los bloques; en el extremo superior derecho se observan los acantilados de la ciudad antigua (Melilla la Vieja) y en el superior izquierdo las áreas del interior del puerto. Se ha destacado el punto de muestreo E16 (ver Figura 5), en el que a los bloques HESI se superpusieron bloques HRSL (sector C). B: detalle de la disposición irregular de los bloques de la escollera exterior del puerto, mostrando los múltiples planos del piso mesolitoral donde se localizan los ejemplares de *P. ferruginea*; en primer plano se observan algunos bloques HESI y al fondo otros HRSL (sector C). C: aspecto reciente de la zona de "El Morrillo" (sector E), donde las obras realizadas han cambiado completamente el perfil de la línea de costa y han supuesto la desaparición de los ejemplares de *P. ferruginea* previamente censados. Las flechas indican aproximadamente la posición de los acantilados naturales; las construcciones situadas a la derecha fueron realizadas en los dos años previos al muestreo (2007-2008), ganando terreno al mar. D: vertido en forma de cascada sobre el acantilado de agua hipersalina procedente de la planta desalinizadora de agua de mar (sector G). E: zona de aporte de bloques de piedra sobre el litoral (entre las dos flechas) para la construcción de la carretera de acceso a la frontera (sector H).

(Right page) Figure 2. Photographs of the Melilla littoral. A: aerial view of the external breakwater of the port, showing the irregular arrangement of the blocks. The cliffs of the ancient town (Melilla la Vieja) are shown at the upper right and the port inner areas at the upper left. The sampling point E16 (see figure 5) in which HESI blocks were placed on top of HRSL blocks is indicated (C sector). B: detail of the irregular arrangement of the blocks of the external breakwater, showing the multiple faces of the mesolittoral zone where the specimens of Patella ferruginea *were located. There are some HESI blocks in the foreground and other HRSL blocks in the background (C sector). C: recent appearance of the "El Morrillo" zone (E sector), where coastal works changed completely the coastline and caused the dissapearance of recorded specimens in previous census of* P. ferruginea. *Arrows indicate the location of the natural cliffs; constructions at the right were done two years before sampling (2007-2008), gaining ground to the sea. D: waterfall-like spillage of hypersaline water over the cliff from the marine water desalination plant (G sector). E: between arrows, zone where rocky blocks were placed over the littoral for the construction of the road to frontier (H sector).*



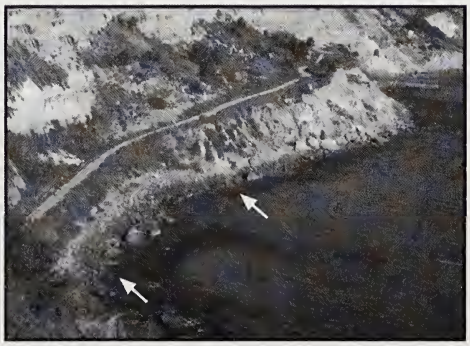
A

B



C

D



E

nado tramo de costa nuevos bloques de roca de tamaño mediano (1-2 m) para crear un talud artificial que estabilizara la pendiente. Esta acción supuso recubrir parte del litoral rocoso natural preexistente (Figura 2E). En el extremo norte de este sector, y coincidiendo con el trazado de la frontera, se construyó un pequeño dique de paredes verticales de hormigón. Aparte de tratarse de un LIC, el acceso a esta zona quedó restringido completamente durante la construcción de la planta desalinizadora en 2006, y así ha permanecido hasta la fecha. Es, además, una zona vigilada permanentemente y de manera intensiva por la Guardia Civil. Por este motivo, a partir del cierre del acceso al litoral de todo este sector cabe presumir un impacto humano nulo sobre *P. ferruginea* por recolección.

Metodología

El muestreo se llevó a cabo entre marzo y junio de 2010, siempre en condiciones de mar en calma y marea baja. Se muestreó la totalidad del litoral de Melilla, a pie o, en las zonas menos accesibles (acantilados, algunos tramos de las escolleras de bloques de hormigón), desde una embarcación neumática. Para estudiar la distribución de la especie, el litoral se dividió en tramos (un total de 148, ver Tabla III), siguiendo el criterio de que cada tramo tuviese características uniformes, tanto en cuanto a la tipología del sustrato (inclinación, rugosidad, grado de exposición al hidrodinamismo, etc.), como en cuanto a la homogeneidad de la densidad de ejemplares de *P. ferruginea*. Los límites entre cada tramo se georreferenciaron mediante GPS o a partir de elementos topográficos reconocibles en la cartografía disponible (PGMOCAM, 2009).

Para cada uno de estos tramos se realizaron estimaciones de la densidad de la especie. La densidad de ejemplares de *P. ferruginea* se ha definido en este trabajo como el número promedio de ejemplares por metro lineal de costa. Posteriormente, se realizó un cálculo de la longitud de cada uno de los tramos de costa a partir de la cartografía disponible (PGMOCAM, 2009), utilizando el software AutoCAD2007®. De este modo, el número de ejemplares adultos presentes en cada tramo de costa se ha calculado como el producto de la densidad y su longitud en metros.

Se ha considerado como parámetro representativo de la talla el diámetro máximo (DM) de la concha, es decir, la longitud máxima de la concha a lo largo de su eje longitudinal, incluyendo las prominencias en su perfil debido a la prolongación de las costillas radiales que habitualmente recorren su superficie.

Las estimaciones de densidad para el estudio general de la distribución de la especie en el litoral de Melilla y para el cálculo de la población se centraron únicamente en los ejemplares de talla superior a 30 mm, por varios motivos. Por una parte, la localización de ejemplares de talla inferior a 30 mm requiere un esfuerzo de muestreo considerable, difícil de llevar a cabo de manera uniforme a lo largo de áreas extensas de litoral. Por otra parte, ese límite corresponde aproximadamente a la talla en la que esta especie alcanza la madurez sexual, que se sitúa entre 18 y 24 mm en las costas de Argelia (Frenkiel, 1975) y en 28 mm (talla de 50% de madurez sexual) en las islas Chafarinas (Guallart y Acevedo, 2006). Por último, como se comenta en el apartado de discusión, la abundancia de ejemplares de talla inferior a 30 mm, que corresponde a juveniles de edad inferior a dos años (Guallart y Acevedo, 2006), puede sufrir variaciones periódicas muy marcadas a corto plazo, debido tanto al éxito del reclutamiento en cada ciclo reproductor anual, como a la elevada mortalidad que tiene lugar durante el primer año de vida (Guallart *et al.*, 2012). De este modo, la evaluación de la población basada únicamente en los ejemplares mayores de 30 mm se centra en un rango de tallas fácilmente muestreable, que tiene una menor variabilidad temporal en su abundancia a corto plazo, y que, en definitiva, constituye el contingente reproductor de la especie.

En el texto, las referencias a "ejemplares adultos" y "ejemplares juveniles"

Tabla II. Datos de los transectos estudiados: fecha de los censos, localización (coordenadas UTM, zona 30, datum WGS84), longitud y descripción general del tipo de costa.
Table II. Data of the studied transects: census data, location (UTM coordinates, zone 30, datum WGS84), length (meters) and general description of the coastline.

Transecto	Fecha	Coordenadas UTM x	Coordenadas UTM y	Longitud (m)	Descripción
T1. Puerto Térmica	18/03/10	505840	3905218	42,0	Escollera de rocas
T2. Dique Puerto I	19/03/10	506975	3905233	6,0	Escollera de bloques de hormigón
T3. Dique Puerto II	20/03/10	506527	3905591	5,60	Escollera de bloques de hormigón
T4. Dique Puerto III	20/03/10	506278	3905601	8,50	Escollera de bloques de hormigón
T5. Horcas Coloradas	01/06/10	505090	3906990	38,3	Islotes, aislados de la línea de costa
T6. Rostrogordo	19/03/10	504878	3907674	10,30	Acantilado bajo, plataforma subhorizontal
T7. Desalinizadora	31/05/10	504745	3908082	9,60	Acantilado bajo, plataforma subhorizontal
T8. LIC Aguadú	31/05/10	504489	3908378	4,30	Plataforma subhorizontal

corresponden a ejemplares de talla mayor y menor de 30 mm, respectivamente. En ningún caso debe entenderse que se haya establecido si los diferentes ejemplares censados habían alcanzado o no la madurez sexual. La densidad de ejemplares por metro lineal de costa se refiere únicamente a ejemplares adultos (ad/m), si bien en algunos casos se hace referencia específicamente a la densidad total de ejemplares, incluidos los juveniles (ej/m).

Se emplearon tres procedimientos para determinar la densidad de ejemplares en cada uno de los tramos, en función de la accesibilidad de la costa y de la abundancia de ejemplares. En las zonas más accesibles se contaron en cada tramo los ejemplares presentes en segmentos de 1 m de longitud lineal de costa, distribuidos aleatoriamente en el interior de cada tramo; la densidad estimada se consideró como el promedio de los distintos valores obtenidos por este procedimiento. En las zonas accesibles, pero con una baja densidad de ejemplares, se contaron todos los ejemplares observados, calculando la densidad como el cociente entre el número de ejemplares y la longitud del tramo de costa. En las zonas menos accesibles, en las que las observaciones se tuvieron que realizar desde la embarcación, se realizaron directamente estimaciones visuales de densidad.

Los recuentos de ejemplares situados en algunas pequeñas rocas separadas de la línea de costa únicamente unos pocos metros, sobre todo en el sector H, se consideraron como correspondientes a la costa cercana, por lo que se sumaron a los resultados obtenidos en la costa para calcular la densidad. En las rocas de mayor tamaño, particularmente en las dos situadas frente a la playa de Horcas Coloradas, el cálculo de la densidad de ejemplares se asignó a la longitud de su perímetro.

Para estimar de la forma más precisa posible la población del dique exterior del puerto de Melilla, se empleó un método diferente. La escollera está constituida principalmente por grandes bloques dispuestos de manera irregular (Figura 2A, B), lo que implica que, en cada lugar, el piso mesolitoral tiene varios planos, correspondientes a las distintas caras de los bloques. Se realizaron censos en 25 puntos de muestreo de la escollera regularmente distribuidos (Figura 5), separados por una distancia aproximada de 50 m. En cada punto se censaron los ejemplares presentes en un segmento del litoral, cuya longitud se calculó siguiendo una línea paralela al trazado general de la escollera. La longitud de cada punto de muestreo varió entre 6,0 y 12,8 m, con un promedio de 10,3 ± 1,6 m. La longitud total censada a lo largo del dique sumando los 25

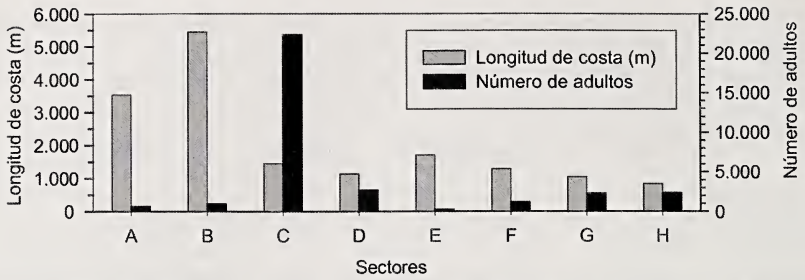


Figura 3. Número estimado de adultos de *Patella ferruginea* (negro) en relación a la longitud de costa en metros (gris) para cada sector.
Figure 3. Estimated number of adult specimens of Patella ferruginea *(black) related to coast length in meters (gray) for each sector.*

puntos de muestreo fue de 256,8 m (aproximadamente el 23% de la longitud total del dique).

Con el fin de estudiar la distribución de tallas, se han definido transectos en 8 puntos del litoral (Figura 1; Tabla II) en los que se censaron y midieron todos los ejemplares hallados, incluidos los juveniles (DM< 30 mm), agrupándolos en intervalos de tallas de 5 mm. Tres de los transectos (T2, T3 y T4) coinciden con tres de los puntos de muestreo establecidos en el dique exterior del puerto. El transecto T5 corresponde a todo el litoral de los dos pequeños islotes situados frente a la playa de las Horcas Coloradas. Los transectos han sido definidos de manera permanente, para que puedan ser utilizados en futuros seguimientos.

Las zonas del litoral en las que se han realizado actuaciones recientes que puedan haber afectado a *P. ferruginea* se han caracterizado en dos grupos: zonas con actuaciones finalizadas después de 2008, es decir, hasta dos años antes de los muestreos, y zonas con actuaciones finalizadas entre 2006 y 2008, es decir, entre 2 y 4 años antes de los muestreos (Tabla I). El intervalo de dos años corresponde aproximadamente al tiempo que los ejemplares de *P. ferruginea* tardan en alcanzar la talla adulta (30 mm de DM) (Guallart y Acevedo, 2006), por lo que en las zonas con actuaciones recientes (< 2 años) sería improbable hallar ejemplares adultos durante los muestreos. El intervalo de cuatro años, en cambio, corresponde aproximadamente al transcurrido desde los muestreos anteriores (González-García *et al.*, 2006; Guallart *et al.*, 2006); en estas zonas podría haberse producido un nuevo asentamiento de ejemplares que, debido al tiempo transcurrido, podrían alcanzar la talla adulta.

RESULTADOS

Distribución por sectores

Patella ferruginea se distribuye de manera heterogénea en los diferentes sectores estudiados (Figura 3). En la Tabla III se resumen los resultados del número de adultos y de su densidad en cada sector. De acuerdo con éstos, la población estimada en Melilla en la primavera de 2010 sería de 32.821 ejemplares adultos. Más de dos tercios de la población (68,1%, 21.952 adultos), se hallaría en el sector C, la escollera exterior del puerto (Tabla III).

En conjunto, se localizaron ejemplares adultos de lapa ferrugínea en el 56,0% del litoral de Melilla formado por sustratos duros.

En la Figura 4 se indica para cada sector el rango de densidad (ad/m) en relación con los porcentajes de litoral rocoso, de litoral inadecuado para la especie (playas) y de zonas de costa rocosa alterada durante los últimos cuatro años por obras en la costa (en las que sería previsible la ausencia o escasez de ejemplares adultos de esta especie).

Tabla III. Características de la costa y número de adultos (ejemplares >30 mm) estimado de *Patella ferruginea* en los diferentes sectores. Se indica para cada sector la longitud total del litoral (en metros), el número de tramos en que se ha dividido para su estudio, los porcentajes de litoral formado por playas, por costa rocosa recientemente alterada por obras (<4 años) y por sustrato duro artificial, el número total de ejemplares estimados, la densidad máxima y la densidad media en las zonas consideradas adecuadas para la especie (el total del litoral, excepto las playas y las zonas alteradas en los últimos cuatro años) y la densidad media de adultos en sustratos naturales y artificiales. (1) Los datos de uno de los tramos se refieren a los censos realizados en 25 puntos de muestreo (ver metodología). (2) Escollera que rodea el terreno ganado al mar. (3) Zona de vertido de la desalinizadora. (4) Talud artificial de rocas para la estabilización de la pista y dique de nueva construcción junto a la frontera.

Table III. Coastal features and estimated number of adults (specimens >30 mm) of Patella ferruginea *in the different sectors. For each sector, the total littoral length (in meters), number of sampled stretchs, percentages of sandy littoral (beaches), rocky shores recently altered by coastal works (<4 years) and artificial hard substrates, the total number of estimated adults, the maximum density and the average density in the zones considered as suitable for the species (the full littoral, except for beaches and zones altered within the last four years) and the average density of adults on natural and artificial substrates are given. (1) Data for one stretch came from a census performed in 25 sampling points (see methodology). (2) Breakwater surrounding ground gained to sea. (3) Zone of spillage of hypersaline water from the desalination plant. (4) Artificial rocky slope constructed as coastal defense for the road to frontier and dike close to frontier.*

	Costa					Ejemplares DM >30 mm				
Sector	Longitud (m)	Nº tramos	% playas	% litoral alterado <4 años	% litoral artificial	Nº total	Densidad máxima	Densidad media adec.	Densidad media natural	Densidad media artificial
A. Paseo Marítimo	3.535	10	56,0	0,0	100,0	638	2,0	0,41	-	0,41
B. Puerto. Interior	5.445	26	0,0	0,0	100,0	969	2,5	0,18	-	0,18
C. Puerto, escollera exterior	1.301	4(1)	0,0	0,0	100,0	22.361	66,5	17,63	-	17,63
D. Melilla La Vieja	1.143	36	13,5	0,0	0,0	2.722	25,0	2,75	2,75	-
E. El Morrillo	1.704	15	16,5	82,7(2)	82,7	261	4,0	1,06	1,06	0,00
F. Horcas Coloradas	1.288	7	69,2	0,0	0,0	1.186	5,5	2,99	2,99	-
G. Rostrogordo	1.044	28	0,0	2,2(3)	0,0	2.314	9,0	2,27	2,27	-
H. LIC Acantilados Aguadú	839	22	0,0	20,9(4)	0,8	2.370	18,0	3,57	2,88	0,17
Total	16.298	148	20,3	10,6	73,1	32.821	66,5	2,82	2,53	2,86

En el sector A, *Patella ferruginea* apareció en la práctica totalidad de la longitud de los espigones que separan los distintos tramos de playa, pero con densidades bajas (<1 ad/m en la mayoría de los tramos, hasta algo más de 2 ad/m en la parte central del dique sur).

En el sector B, la especie no apareció en la mayor parte del litoral (71,9%), especialmente en las zonas más confinadas de ambos puertos deportivos y en las paredes verticales de hormigón que constituyen los muelles de atraque del puerto comercial. Se encontró en densidades bajas (< 1 ad/m) en algunas zonas, como los muros verticales del antiguo descargadero de mineral y en una zona de escollera de piedras localizada junto al edificio del Quinto Centenario (T1), en torno a un punto de vertido del agua de refrigeración de la central térmica de la ciudad. A lo largo de la mayor parte de la escollera de tetrápodos de hormigón del Puerto Noray, construido en la década de 1990, se observó la presencia de *Patella ferrugi-*

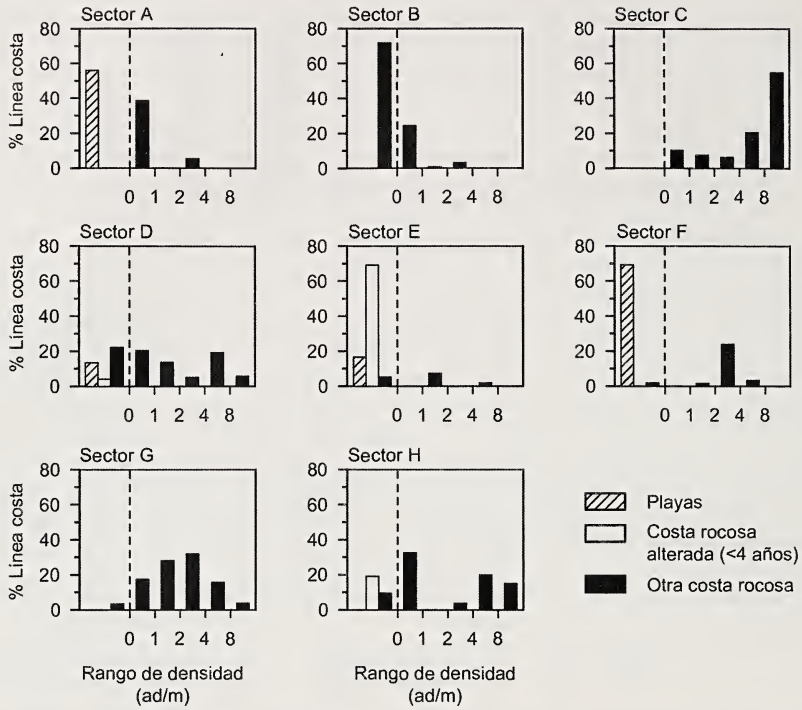


Figura 4. Rangos de densidad (adultos/m) de *Patella ferruginea* en cada sector, indicando los porcentajes de litoral formado por playas (inadecuado para la especie), por costa rocosa alterada en los últimos cuatro años (en la que es previsible la ausencia o escasez de adultos) y por otros tipos de costa rocosa. *Figure 4. Density ranges (adults/m) of* Patella ferruginea *in each sector. The percentages of sandy littoral (beaches, unsuitable for the species), rocky shore altered within the last four years (in which absence or scarcity of adults is expected) and other types of rocky shore are indicated.*

nea, alcanzando densidades de 2,5 ad/m en algunos puntos (Figura 6).

El sector C fue la zona en la que se observó una mayor densidad. En la Figura 5 se muestra la localización de los censos realizados en la escollera exterior del puerto y la densidad de adultos obtenida en cada uno de ellos, que fue alta, pero heterogénea. En 16 de los 25 censos, la densidad superó los 10 ad/m, y en 20 de ellos, los 5 ad/m. La densidad promedio fue de 19,84 ± 16,80 ad/m. Las máximas densidades se hallaron en la zona central de la escollera (puntos E07 a E15), con una densidad promedio de 32,00 ± 17,6 ad/m y una densidad máxima absoluta de 66,46 ad/m (E12). Parte de esta heterogeneidad puede relacionarse con las características de los bloques que constituyen la escollera (Figura 5a). En la zona formada por bloques HESI, se obtuvieron los valores máximos de densidad, con un promedio de 23,81 ± 17,04 ad/m (n= 19), mientras que en los bloques HRSL el promedio fue de 7,26 ± 7,70 ad/m (n= 6). Estas diferencias son estadísticamente significativas (ANOVA, $F_{1,23}$= 5,92, p= 0,032).

En el sector D, *P. ferruginea* estaba bien representada, pero con densidades heterogéneas (Figura 6). No se hallaron ejemplares en varios tramos que comprenden el 22,1% del litoral y que corresponden a algunas rocas junto a la playa de las Cuevas del Conventico, en zonas relativamente abrigadas y cercanas a los fondos arenosos, así como a las paredes verticales más protegidas de la ensenada de los Galápagos. Sin embargo, se encontraron densidades de hasta 25 ad/m en algunas plataformas rocosas

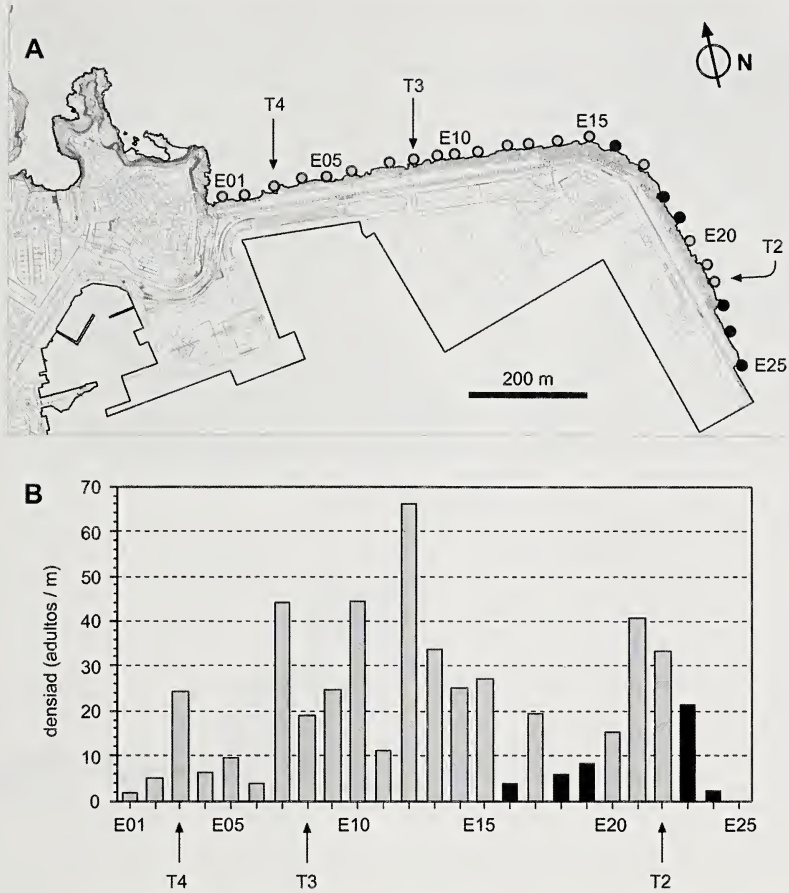


Figura 5. A, localización de los puntos (E01 a E25) donde se realizaron los censos en la escollera del puerto de Melilla (sector C). En negro, puntos con bloques de hormigón reciente de superficie lisa (HRSL), y en gris puntos con bloques erosionados de superficie irregular (HESI). B, Densidad de adultos (>30 mm DM). Las flechas en A y B indican la coincidencia entre los puntos de censo de ejemplares adultos (E03, E08, y E22) y los transectos en que se realizó un censo exhaustivo tanto de adultos como de ejemplares juveniles (T4, T3 y T2, respectivamente).
Figure 5. A, location of the census points (E01 to E25) in the external breakwater of the Melilla port (sector C). In black, points with recent concrete blocks with smooth surface (HRSL); in grey, points with eroded concrete blocks of irregular surface (HESI). B, density of adults (>30 mm of maximum diameter). Arrows in A and B indicate the coincidence among points of census of only adult specimens (E03, E08, y E22) and transects in which an exhaustive census of adults and juvenile specimens were performed (T4, T3 y T2, respectively).

cercanas a la playa de las Cuevas del Conventico.

En el sector E apareció únicamente en la zona de acantilados naturales cercana a la ensenada de los Galápagos (Figura 6), en general con densidades bajas, aunque en algún tramo llegó a alcanzar los 4 ad/m. No se encontró ningún ejemplar adulto en toda la zona de escollera nueva, que constituye la mayor parte del sector. Aunque se realizaron muestreos en los primeros tramos de escollera que comenzaron a construirse (en su extremo N) a principios de

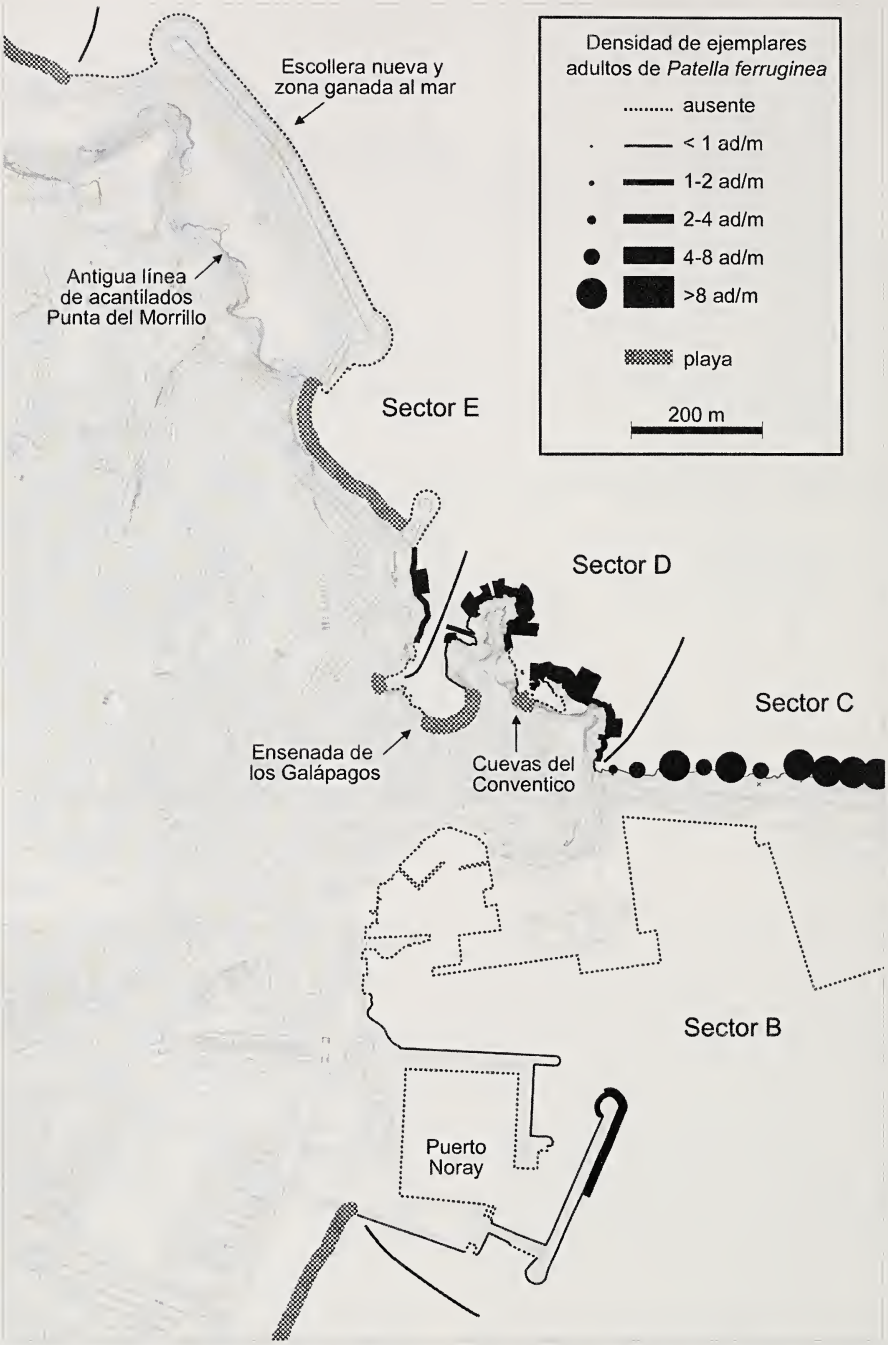


Figura 6. Densidades de adultos de *Patella ferruginea* en los sectores B, D y E. Los datos del sector C (dique exterior del puerto) se han representado como círculos de diámetro proporcional a la densidad de la especie en los puntos de muestreo seleccionados (ver Figura 5).
Figure 6. Densities of adults of Patella ferruginea *in sectors B, D and E. Data for sector C (the external breakwater of the port) are represented by black circles of a diameter proportional to the density in the selected sampling points (see Figure 5).*

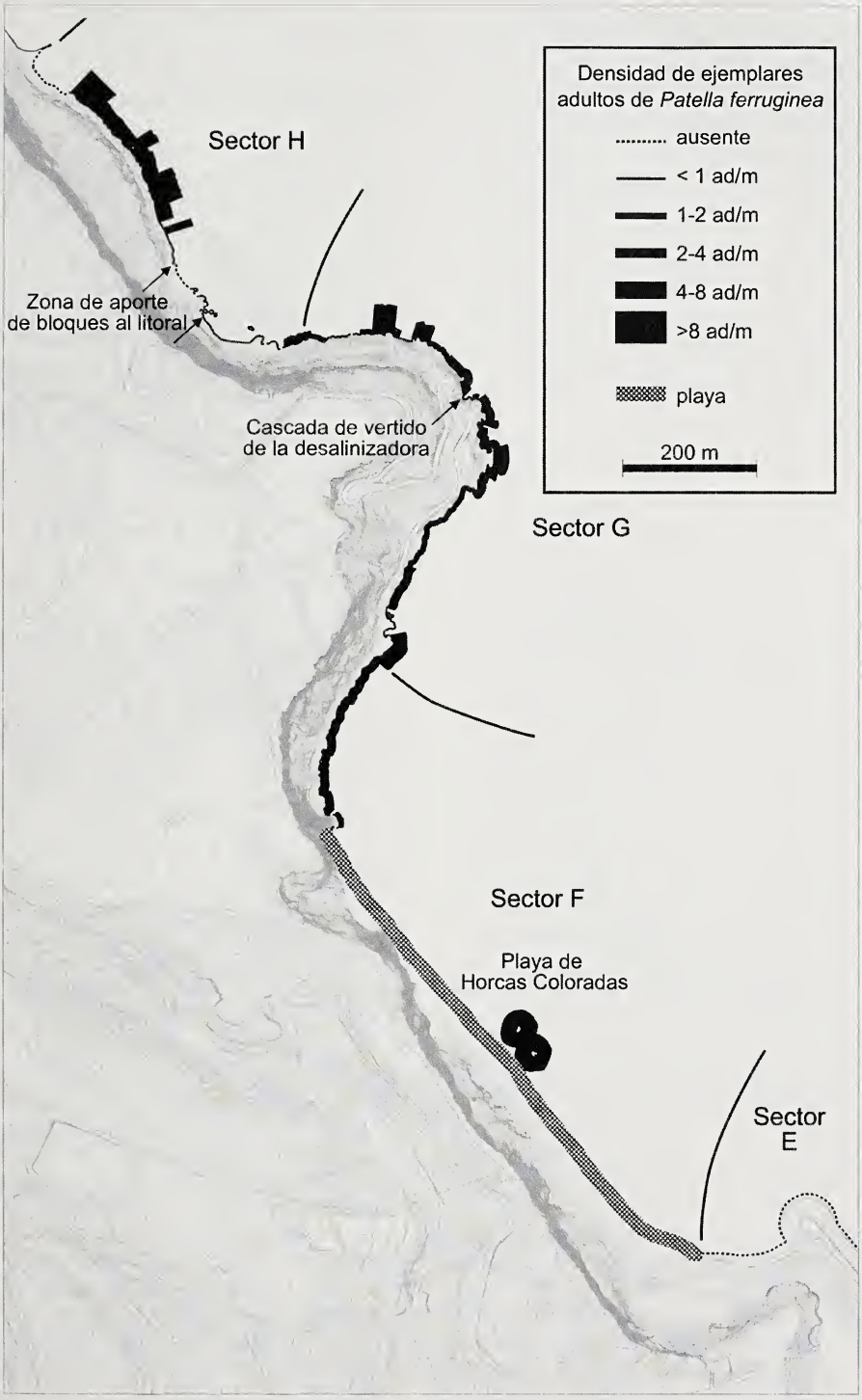


Figura 7. Densidades de adultos de *Patella ferruginea* en los sectores F, G y H.
Figure 7. Densities of adults of Patella ferruginea *in sectors F, G and H.*

2007, y cuyas rocas ya llevarían por lo tanto unos 3 años instaladas, no se detectaron ni siquiera juveniles.

En el sector F, *P. ferruginea* estaba asimismo bien representada en la mayor parte del litoral rocoso al norte de la playa de Horcas Coloradas. Salvo una pequeña prominencia rocosa situada en el extremo N de la playa, en la que el número de adultos era escaso, en el resto de la zona la densidad se situó en torno a 3 ad/m. En las rocas aisladas de la costa situadas frente a la playa (T5) se censaron un total de 226 adultos, lo que representa una densidad media superior a los 5 ad/m (Figura 7).

En el sector G, a pesar de la habitual presencia humana, tanto de bañistas como de pescadores deportivos, se encontraron densidades moderadas (Figura 7), entre 1 y 4 ad/m, con máximos de 9 ad/m. La zona de vertido de agua hipersalina de la planta desalinizadora en forma de cascada no se muestreó por razones de seguridad, pero se ha asumido que *P. ferruginea* estaba ausente. Es de destacar, sin embargo, que en los tramos de acantilado aledaños a la caída de agua, apenas a unos metros de distancia de ella, se localizaron varios ejemplares adultos. En los tramos situados a menos de 20 m de distancia de esta cascada, se midieron densidades próximas a los 2 ad/m.

En el sector H (LIC Acantilados Aguadú) la especie apareció de forma casi constante, al menos en las rocas naturales, si bien su densidad fue bastante heterogénea, desde algunos tramos en los que estaba ausente hasta algunas rocas en forma de plataforma subhorizontal en las que alcanzó los 18 ad/m (Figura 7). Sin embargo, en los tramos recientemente alterados solamente se hallaron ejemplares adultos en una pequeña porción del talud de rocas construido para la protección de la carretera de acceso a la frontera entre 2005 y 2006, especialmente en los lugares en los que el material aportado recientemente dejaba aflorar bloques preexistentes de gran tamaño (Figura 2E). En otras partes de este talud artificial se localizaron algunos juveniles, pero no adultos. En el pequeño dique de hormigón junto a la frontera se localizaron dos ejemplares adultos.

Presencia en zonas naturales y artificiales

En Melilla, *P. ferruginea* se halló tanto sobre sustratos duros naturales como artificiales. Las estructuras de origen artificial constituyen el 73,1% de la longitud del litoral de sustrato duro, mientras que la costa rocosa natural representa el restante 26,9%. El 73,0% del total estimado de ejemplares se localizó sobre sustratos artificiales, mientras que el 27,0% restante se encontró sobre sustratos rocosos naturales. Sin embargo, esta aparente similitud porcentual no es real: en más de la mitad (53,6%) del litoral artificial no aparecieron ejemplares adultos, mientras que sólo en el 19,8% del litoral natural no se encontraron adultos.

La parte principal (75,0%) del litoral artificial donde *P. ferruginea* no apareció corresponde a las zonas más abrigadas del interior de los dos puertos deportivos y a los muros verticales de la zona de atraque del puerto comercial. Otra parte importante (23,1%) corresponde a zonas en las que se realizaron obras costeras en los dos años anteriores a los muestreos. Ambos tipos de zonas suman el 98,1% del litoral artificial donde no se encontró la especie.

En el litoral rocoso natural, la lapa ferrugínea estaba ausente en enclaves con características diferentes. Un 38,3% del litoral en el que la especie no se halló corresponde a algunas zonas del sector H que han sufrido obras en los últimos cuatro años. Por otra parte, el tramo del vertido de la planta desalinizadora, localizado en un acantilado natural, donde se ha asumido que no habría ejemplares de *P. ferruginea*, representa el 3,6% del litoral rocoso natural donde está ausente. Prácticamente el resto de las zonas naturales donde no se encontró la especie corresponde a enclaves rocosos someros, próximos a playas arenosas (extremo norte de la playa de Horcas Coloradas), y algunos de ellos además situados en zonas muy protegidas (interior de la ensenada de los Galápagos).

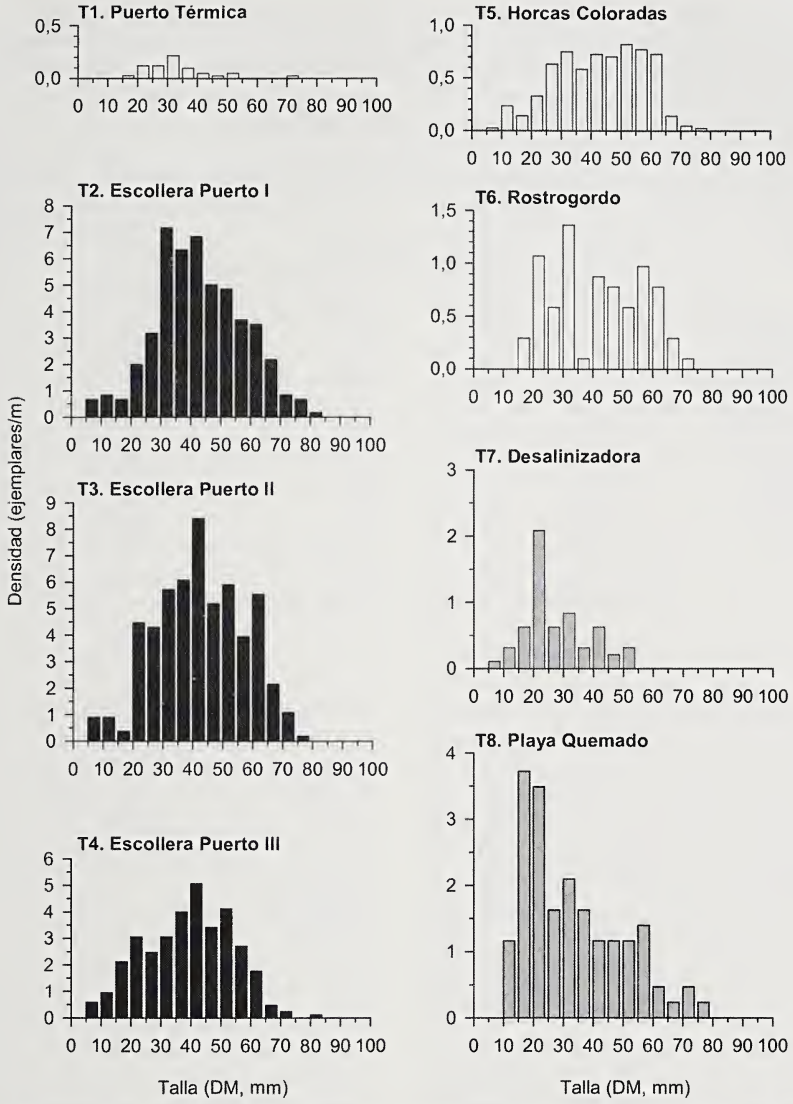


Figura 8. Distribución de frecuencia de tallas para cada uno de los transectos. La escala del eje de ordenadas no es equivalente en todas las gráficas; el color de las barras agrupa a aquellas con la misma proporción de escala.

Figure 8. Size frequency distribution (DM, maximum diameter) for each transect. Y-axis scale is not equivalent in all graphs; bar colour group graphs with the same scale.

Distribución de tallas

En la Figura 8 se representa la distribución de frecuencias de tallas en los censos realizados en los transectos, en los que se censaron y midieron 1.427 ejemplares en total. En la Tabla IV se sintetizan algunos de los parámetros de la población obtenidos a partir de estos censos.

La densidad de adultos en los transectos varió entre 0,45 y 44,11 ad/m, con un promedio de 14,73 ± 15,22 ad/m. Los mayores valores (> 24 ad/m) se alcanzaron en los tres transectos localizados en la

Tabla IV. Resultados de los censos realizados en los 8 transectos. Se indica para el total de ejemplares de cada transecto la densidad (ej/m), la talla máxima (DM máx) y el porcentaje de ejemplares de DM< 30 mm (juveniles). Para los adultos (DM> 30 mm) se indican la densidad (ad/m), la talla media (DM med) y la desviación estándar (DE).
Table IV. Results of census carried out for each transect. Density (in/m), maximum size (DM máx) and percentage of individuals of DM< 30 mm (juveniles) are indicated for the total specimens. For adults (DM> 30 mm), density (ad/m), average size (DM med) and standard deviation (DE) are indicated.

Transecto	Total			Sólo adultos (DM> 30 mm)	
	Densidad (ej/m)	DM máx (mm)	% DM< 30 mm	Densidad (ad/m)	DM med ± DE (mm)
T1. Puerto Térmica	0,71	72,5	36,7	0,45	39,6 ± 10,5
T2. Escollera Puerto I	48,50	84,2	26,9	24,94	47,5 ± 12,0
T3. Escollera Puerto II	55,00	77,5	19,8	44,11	48,4 ± 11,2
T4. Escollera Puerto III	34,12	80,1	26,9	24,94	46,8 ± 9,9
T5. Horcas Coloradas	7,42	77,8	20,4	5,28	48,8 ± 10,7
T6. Rostrogordo	7,77	71,8	25,0	5,83	48,7 ± 11,8
T7. Desalinizadora	6,04	54,0	62,1	2,29	40,0 ± 7,19
T8. LIC Aguadú	20,00	77,5	50,0	10,00	47,2 ± 12,5
Media	22,45	74,4	33,5	14,73 ± 15,22	47,6 ± 11,2

escollera exterior del puerto, en la que la superficie disponible se ve muy incrementada respecto a la longitud lineal del transecto debido a las diferentes caras de los bloques. La densidad más baja (0,45 ad/m) se obtuvo en el transecto realizado en el interior de la zona portuaria (T1).

En la mayoría de los transectos se encontraron ejemplares con un amplio rango de tallas, lo que indica la presencia tanto de reclutas y juveniles como de adultos. El porcentaje de juveniles en todos los transectos es cercano o superior al 20% y está por encima del 50% de los ejemplares censados en dos transectos (T7 y T8). La talla media de los adultos se sitúa entre 39,6 y 48,8 mm. En los transectos T1 y T7 la presencia de adultos de talla > 50 mm es muy baja, inferior a 0,4 ad/m. La mayor talla registrada fue de 84,2 mm.

DISCUSIÓN

Evolución reciente de la población de Melilla

Los resultados de este trabajo suponen una estimación de la población de *Patella ferruginea* en Melilla (32.821 adultos) que casi duplica a la obtenida en los trabajos precedentes (14.000-16.500 ejemplares totales, González-García *et al.*, 2006; 19.400 adultos, Guallart *et al.*, 2006). No obstante, esta variación no debe ser interpretada en absoluto como un aumento de la población durante los cuatro años transcurridos, sino que debe atribuirse sobre todo al mayor esfuerzo y a la mayor precisión de los muestreos realizados en el presente estudio, sobre todo en la zona de mayor abundancia de la lapa, la escollera exterior del puerto, en la que se ha estimado una población de 22.361 ejemplares adultos, frente a los 13.518 adultos estimados en 2006. Lo mismo puede decirse del sector H (LIC de los Acantilados de Aguadú), en el que el acceso a pie no fue posible en 2006 por haber comenzado las obras de la pista hasta la frontera, mientras que en 2010 se pudo realizar el muestreo a pie y con mayor detalle (2.370 ejemplares estimados en 2010, frente a 798 en 2006). Otro caso semejante podría ser la el de zona de la playa de las Cuevas del Conventico (sector D), donde la posibilidad de realizar los censos con mayor detalle

puede considerarse la principal causa de que la estimación de adultos pasara de 141 en 2006 a 1.727 en 2010. Considerando solamente estos casos, el mayor esfuerzo de muestreo explicaría el 89,4% del incremento total registrado respecto a 2006 (12.001 ejemplares adicionales respecto a un incremento total de 13.421 adultos).

Por otra parte, el número de tramos en que se dividió la costa fue diferente en los dos censos: 94 en 2006, frente a 148 en 2010, lo que indica la mayor resolución con que se ha caracterizado y estudiado el litoral. Sin embargo, la no coincidencia de los límites de cada uno de los tramos limita en algunos casos la precisión en las comparaciones de abundancia de ejemplares.

Por otro lado, las actuaciones humanas realizadas en el litoral de Melilla durante los últimos cuatro años han afectado en particular a los sectores E y H, y, en menor medida, al sector G. La comparación de los resultados obtenidos por GUALLART *ET AL.* (2006) con los del presente trabajo muestran que las obras realizadas entre 2007 y 2008 en el sector E para la estabilización de la escombrera situada junto a la incineradora, en las que además se ganó terreno al mar a lo largo de unos 650 m de costa acantilada natural, habrían supuesto la desaparición por aterramiento de unos 1.200 ejemplares adultos de *P. ferruginea*, de los cuales 331 estaban localizados en la roca situada a unos 35 m de la costa, conocida como "peña aislada", que quedó integrada en el terreno ganado al mar.

La comparación del sector H para evaluar el impacto de las obras de construcción de la pista hasta la frontera es difícil, porque, como se ha dicho, en 2006 no se pudo acceder a este tramo de costa desde tierra por haber comenzado las obras. Por este motivo, en 2006 se definieron únicamente cuatro tramos de costa para este sector, frente a los 22 tramos definidos en 2010. La diferencia en el recorrido de los tramos de costa establecidos en ambos estudios no permite comparar todas las zonas en las que se observa una afección directa de las obras por la presencia evidente de un terraplén reciente. No obstante, y a modo de ejemplo, en el extremo NW del litoral, ya en el límite con la frontera, se definió en 2006 un tramo de 104 m en el que se halló una densidad media de 4,5 ad/m, estimándose, por tanto, una población total de 468 adultos. En esta misma zona, cuyo litoral en 2010 estaba formado por un talud artificial de rocas aportadas recientemente, no se halló ningún adulto de *P. ferruginea*.

Respecto a la zona de acantilados del sector G, donde se localiza el vertido de agua hipersalina de la planta desalinizadora, no se dispone de datos de 2006 exactamente para la zona afectada por la cascada. Sin embargo, en el tramo de costa definido en 2006 que actualmente incluiría la zona de vertido, de unos 100 m de longitud, se estimaron 359 ejemplares adultos en 2006, mientras que en este trabajo se han estimado 169 ejemplares. No existe información acerca de la influencia de los cambios de salinidad sobre *Patella ferruginea*, aunque se ha estudiado en otras especies de lapas (ARNOLD, 1957; DE PIRRO, SANTINI Y CHELAZZI, 1999; FIRTH Y WILLIAMS, 2009). Al margen de que pueda cambiar en el futuro la localización o el tipo de vertido de esta planta desalinizadora, una de las tareas prioritarias de seguimiento sería evaluar el impacto de este vertido en la supervivencia de los ejemplares y la evolución de la población afectada.

Distribución general de la especie en Melilla

Patella ferruginea se encontró a lo largo del 56,0% del litoral de sustratos duros de Melilla. Entre las zonas en las que estaba ausente se incluyen aquellas en las que se han realizado obras recientemente y en las que no ha transcurrido tiempo suficiente para la recolonización, en el supuesto de que las condiciones sean propicias. Tampoco se encontró en las zonas más confinadas del interior del puerto, en las que no cabe esperar su presencia. En general, se ha descrito que la lapa ferrugínea prefiere las zonas con hidrodinamismo moderado-alto (BOUDOURESQUE Y LABOREL-DEGUEN, 1986;

Porcheddu y Milella, 1991; Boumaza y Semroud, 2001; Guallart *et al.*, 2006), por lo que su ausencia en las zonas portuarias interiores podría responder a esta preferencia. Un caso especial es el puerto de Ceuta, en cuyo interior se han localizado importantes contingentes de ejemplares, lo que ha sido atribuido a las particulares características de este puerto, abierto al mar en dos zonas opuestas, de forma que permite la circulación del agua en su interior (Guerra-García *et al.*, 2004; Rivera-Ingraham *et al.*, 2011a).

Si se excluyen los tramos de costa con estas dos características (zonas muy confinadas y aquellas en las que se ha transformado recientemente el litoral), se puede considerar que *Patella ferruginea* está presente a lo largo de prácticamente la totalidad (92,8%) del litoral potencial para la especie en Melilla, tanto en la costa rocosa natural como sobre sustratos duros artificiales.

Distribución en estructuras litorales artificiales

La abundancia de *Patella ferruginea* sobre sustratos artificiales y, en particular, sobre espigones y escolleras de puertos, ha sido señalada en numerosas zonas de su área de distribución actual (Doneddu y Manunza, 1992; Guerra-García *et al.*, 2004; Espinosa *et al.*, 2005; Espinosa *et al.*, 2009; Arroyo *et al.*, 2011; Rivera-Ingraham *et al.*, 2011a). En Melilla, el 73,0% de los adultos se localizó sobre sustratos artificiales y más de dos tercios del total (68,1%) se hallaron en la escollera exterior del puerto.

El aumento a nivel global de las obras en el litoral ha abierto el debate sobre si estas estructuras artificiales pueden compensar la pérdida del hábitat natural de las especies litorales y representar un hábitat alternativo para sus comunidades (Thompson *et al.*, 2002). Sin embargo, diversos estudios recientes han puesto de manifiesto diferencias importantes entre las comunidades biológicas de estas estructuras artificiales intermareales y las de la costa rocosa original, en términos tanto de composición específica como de abundancia relativa de las diferentes especies (Chapman, 2003; Chapman y Bulleri, 2003; Bulleri y Chapman, 2004; Moreira *et al.*, 2006). Además, se han hallado diferencias marcadas en aspectos biológicos fundamentales de la dinámica de la población de las especies, como la fecundidad o el éxito del reclutamiento (Bulleri, 2005; Moreira *et al.*, 2006), lo que ha llevado a varios de estos autores a concluir que las estructuras litorales artificiales no son sustitutivas de las costas rocosas naturales (Chapman y Bulleri, 2003; Moreira *et al.*, 2006).

En el caso de *Patella ferruginea*, la información disponible es insuficiente. La proliferación de obras costeras y la consiguiente destrucción de los hábitats naturales ha sido señalado como una de las causas probables de su regresión (Ramos, 1998; Templado, 2001). Por otra parte, existe la posibilidad, aún no estudiada, de que las estructuras artificiales más o menos largas y perpendiculares a la costa, como los espigones y las escolleras, funcionen como "trampas de larvas", y, por lo tanto, actúen como barreras a la dispersión natural de esta especie, como apuntan Rivera-Ingraham *et al.* (2011a). Sin embargo, algunos autores han señalado la importancia que las obras costeras o algunos puertos pueden tener en la conservación de la especie (Guerra-Garcia *et al.*, 2004), incluso planteando la posibilidad de crear figuras legales de protección para aquellas estructuras artificiales, sobre todo portuarias, con importantes poblaciones de *P. ferruginea* (García-Gómez, López-Fé, Espinosa, Guerra-García y Rivera-Ingraham, 2010). Otros autores han sugerido que un diseño adecuado de estas estructuras artificiales podría contribuir al mantenimiento de otras especies intermareales amenazadas, como la lapa *Patella candei* (Martins, Thompson, Neto, Hawkins y Jenkins, 2010).

Por su parte, la valoración de la importancia de la presencia de *P. ferruginea* en sustratos artificiales, realizada en su conjunto, ha generado resultados contradictorios. En Ceuta, Guerra-

GARCÍA *ET AL.* (2004) indicaron que, en dichos sustratos, esta especie muestra una densidad de ejemplares mayor a la vez que una talla media menor, si bien posteriormente RIVERA-INGRAHAM *ET AL.* (2011a) no hallaron en esa misma localidad diferencias en estos parámetros entre sustratos naturales y artificiales. Uno de los factores que puede contribuir a este hecho es no tanto el carácter artificial o natural del sustrato, sino el material del que están formados. En el presente estudio, se ha constatado que los bloques de hormigón de superficie lisa (HRSL), con baja rugosidad y de relativamente reciente instalación, presentaban en promedio una densidad significativamente menor de ejemplares de *P. ferruginea* que los bloques más antiguos (HESI), formados en parte por rocas procedentes de canteras locales. Estos resultados son similares a los obtenidos por RIVERA-INGRAHAM *ET AL.* (2011a) en el puerto de Ceuta, donde en las zonas de escollera formadas por bloques calcáreos, la densidad era hasta seis veces mayor que en las de bloques de hormigón de superficie lisa.

El papel de las estructuras artificiales en la distribución y conservación de la lapa ferrugínea constituye, pues, otra de las líneas de investigación de atención prioritaria en un futuro inmediato.

Comparación con otras poblaciones

La comparación entre las distintas poblaciones de *Patella ferruginea* no es fácil, al menos por tres motivos: 1) las diferencias en la representatividad de los tramos de costa (transectos) de realización de los censos, 2) las diferencias en el contingente de población seleccionado para calcular la densidad (número total de ejemplares o número de adultos) y 3) el método de estimación de la población total de cada localidad.

En cuanto al primero de ellos, el número y la longitud total de los transectos estudiados varía ampliamente en los diferentes trabajos publicados recientemente, entre los alrededor de 100 m de litoral censados por BOUDOURESQUE Y LABOREL-DEGUEN (1986) en la isla de Zembra (Túnez) o por BOUMAZA Y SEMROUD (2001) y ESPINOSA (2009) en las islas Habibas (Argelia), o los más de 6.600 m de litoral muestreados por RIVERA-INGRAHAM *ET AL.* (2011a) en Ceuta. Lógicamente, la precisión en la estimación de la población es superior cuando se censan un mayor número de transectos y una mayor longitud de litoral; en definitiva, cuando el esfuerzo de muestreo es mayor.

Una segunda cuestión es si, con fines de caracterizar la abundancia de una población, el censo debe incluir a todos los ejemplares, o únicamente, tal y como se propone en el presente trabajo, a los ejemplares a partir de un determinado rango de tallas, en este caso de DM> 30 mm (considerados como ejemplares adultos).

La abundancia de juveniles, especialmente de reclutas del primer año de vida, puede presentar variaciones muy marcadas, tanto estacionales como en función del éxito del reclutamiento tras cada periodo reproductor (RIVERA-INGRAHAM *ET AL.*, 2011a; GUALLART *ET AL.*, 2012). GUALLART *ET AL.* (2012), en un seguimiento realizado en las islas Chafarinas entre 1999 y 2011, señalaron una variabilidad interanual muy elevada en la densidad de reclutas, con un promedio de 9,14 reclutas/m, que en algunos años podía ser mucho mayor, superando los 50 reclutas/m. Estos autores indicaron además que a lo largo del primer año de vida la mortalidad de los reclutas es muy elevada, especialmente durante el verano. Aunque el estudio de la abundancia de reclutas o juveniles es fundamental para evaluar el estado de conservación de las poblaciones de *P. ferruginea*, en nuestra opinión estos datos deberían ser utilizados fundamentalmente para evaluar el éxito reproductor de la especie y la capacidad de renovación entre generaciones (GUALLART *ET AL.*, 2011) y no para estimar la población de cada zona. Ésta debería centrarse únicamente en la abundancia de ejemplares adultos (DM> 30 mm), tal y como se plantea en el presente trabajo.

El porcentaje de juveniles (DM< 30 mm) en los censos realizados en diferentes trabajos muestra una gran variabili-

dad, oscilando entre el 0,8% (isla de Alborán, Barba, Nevado, Moreno, de la Linde, Remón, De la Rosa, Arroyo, Fernández-Casado, Gómez, Barrajón y Gordillo, 2006) y el 47,7% (isla Plana, Argelia; Espinosa, 2009). En la Tabla V se resumen algunos ejemplos. En varias de las zonas donde se han encontrado mayores densidades totales de ejemplares de *P. ferruginea*, esto puede ser en parte atribuido a que el porcentaje de juveniles era muy elevado, superando el 30% del total de ejemplares censados: tal es el caso de las islas Habibas y la isla Plana (Espinosa, 2009), Ceuta (Rivera-Ingraham *et al.*, 2011a) y de Melilla en el presente estudio.

En tercer lugar, el método de estimación de la población total en cada localidad ha sido también muy variable, e incluye desde una extrapolación tentativa realizada en un trabajo pionero llevado a cabo en la isla de Zembra (Túnez), calculado a partir del muestreo de solamente el 0,24% del litoral (Boudouresque y Laborel-Deguen, 1986) hasta el recuento exhaustivo de todos los ejemplares, realizado en localidades con una extensión de litoral reducida (como la isla de Alborán, Paracuellos *et al.*, 2003; Barba *et al.*, 2007; Moreno y Arroyo, 2008) o con una densidad de ejemplares muy baja (bahía de Algeciras y Gibraltar, Espinosa *et al.*, 2005; diferentes tramos del litoral de Andalucía, Arroyo *et al.*, 2011). La fiabilidad de los resultados depende del porcentaje del litoral muestreado y de la representatividad de este litoral respecto al total de la zona estudiada. Así, las estimaciones realizadas por Rivera-Ingraham *et al.* (2011a), que censaron el 34,0% del litoral de Ceuta, o de Arroyo *et al.* (2011) que censaron el 20,7% del litoral de la isla de Alborán pueden considerarse más fiables que la ya mencionada de Boudouresque y Laborel-Deguen (1986) para Zembra, o la más reciente de Espinosa (2009) en las Islas Habibas (Argelia), en la que se estimó la población global muestreando menos del 2% de su litoral.

En el presente trabajo, la estimación de la población de *P. ferruginea* en Melilla se basa en el muestreo del 100% de su litoral, lo que no implica el recuento de la totalidad de ejemplares presentes en él, sino la estimación metódica de la densidad de ejemplares a lo largo de su recorrido. Este método tiene la ventaja de que pueden detectarse enclaves con densidades inusualmente elevadas o incluso evaluar un parámetro importante: el porcentaje de costa rocosa en que *P. ferruginea* está ausente. Además, la estimación de la población no depende de la selección de tramos de costa muestreados en cada enclave (es decir, del número de transectos realizados y de la longitud total de éstos, de la aleatoriedad o de la representatividad de la ubicación de los transectos). La principal desventaja es que implica realizar estimaciones promedio de densidad en diferentes tramos de costa, que pueden no ser sencillas de realizar en zonas con elevada densidad de ejemplares y/o escasa accesibilidad. En tramos poco accesibles, en los que el muestreo se realiza desde una embarcación, el cálculo de la densidad se lleva a cabo mediante estimaciones visuales y requiere la participación de un equipo con experiencia no sólo en la identificación de ejemplares sino, sobre todo, en la evaluación de la densidad media. El presente trabajo ha sido realizado por un equipo que había desarrollado esta metodología previamente en las islas Chafarinas y que, a partir de los resultados obtenidos, había podido verificar la estrecha correlación entre las estimaciones visuales y los censos llevados a cabo en determinado transectos en el litoral (Guallart *et al.*, 2006).

En el caso de la escollera exterior del puerto de Melilla, la principal dificultad fue que el litoral no es lineal, sino que está constituido por grandes bloques con una disposición muy irregular, en los que es posible hallar ejemplares de *P. ferruginea* en sus diferentes caras. Para superar esa dificultad, se censaron los adultos presentes en las diferentes caras de los bloques en un total de 25 tramos cortos de la escollera. La precisión de la estimación total obtenida para el trazado de la escollera de bloques

Tabla V. Densidad de ejemplares de *Patella ferruginea* registrada en distintas localidades a partir de datos de censos en transecto. Se indica para cada localidad la referencia bibliográfica, el número de transectos realizados (n) y la longitud total cubierta en metros (LT), la densidad total de ejemplares máxima (Max) y media, el porcentaje de ejemplares de DM< 30 mm (juveniles) y la densidad de ejemplares de DM> 30 mm (adultos) máxima (Max) y media. Los números seguidos de asterisco corresponden a datos no aportados en el texto de las publicaciones y calculados indirectamente a partir de las gráficas que aparecen en ellas.

Table V. Densities of individuals of Patella ferruginea *registered in different localities from data obtained from censuses in transects. Reference, number of transects performed (n) and total length covered in meters (LT), maximum (Max) and average (Media) total density of individuals, percentage of individuals of DM< 30 mm (juveniles) and maximum (Max) and average (Media) density of individuals of DM> 30 mm (adults) are indicated for each locality. Numbers followed by an asterisk correspond to data that do not appear in the text of these publications, but here calculated from the graphs published.*

Localidad	Referencia	Transectos		Densidad total		% DM< 30 mm	Densidad DM> 30 mm	
		n	LT (m)	Max	Media		Max	Media
Isla de Alborán	BARBA *ET AL.* (2006)	10	~2.000	0,12	0,07	0,8*	0,12*	0,07*
Ceuta	RIVERA-INGRAHAM *ET AL.* (2011)	30	6.608	35,14	4,09	37,3	3,90	1,65
Islas Habibas (Argelia)	ESPINOSA (2009)	12	120	25,3	4,81	32,8*	9,8*	3,23*
Isla Plana (Argelia)	ESPINOSA (2009)	2	20	35,3	22,00	47,7*	15,8*	11,50*
Islas Chafarinas	APARICI-SEGUER, GUALLART-FURIÓ Y VICENT-RUBERT (1995)	16	800	10,75	5,28	21,0*	9,28*	4,17*
Melilla	GONZÁLEZ-GARCÍA *ET AL.* (2006)	6	300	8,0	5,54	8,6*	6,4*	4,59*
	Presente estudio	8	129	55,0	20,55	33,5	44,11	14,73
	Presente estudio (excepto escollera del puerto)	5	109	20,0	8,23	38,8	10,00	4,77

(22.095 adultos) puede valorarse teniendo en cuenta que los tramos censados representan aproximadamente el 23% de la longitud total de la escollera y que se llegaron a censar directamente en ellos 4.771 ejemplares adultos.

Los datos de densidad de ejemplares en Melilla, calculados a partir de censos en transecto, son en orden de magnitud semejantes a los de otras localidades con importantes poblaciones de la especie, como Ceuta, las islas Habibas o las islas Chafarinas (Tabla V).

Considerando todos los individuos (adultos y juveniles), los valores máximos de densidad obtenidos en este estudio (55 ej/m) son superiores a los obtenidos en otras localidades (ver Tabla V). Sin embargo, estos valores máximos pueden no ser representativos de la densidad en cada localidad, pues pueden corresponder a zonas en que, aparte de una densidad relativamente elevada, se puedan dar factores que la acentúen. Un ejemplo sería el de zonas que, como la escollera exterior del puerto de Melilla, tengan unas características topográficas especiales y presenten una elevada superficie para una misma longitud lineal de costa. Lo mismo ocurriría en zonas naturales con abundantes grietas e irregularidades del sustrato. Otro ejemplo serían las zonas con amplias plataformas subhorizontales, en las que densidades moderadas de ejemplares en relación a la superficie podrían reflejarse como muy elevadas si se considera la densidad por metro lineal.

Por otra parte, el valor medio de densidad total de ejemplares (adultos y juveniles) obtenido en este trabajo (20,55 ej/m), es similar a los 22 ej/m señalados por ESPINOSA (2009) para la isla Plana

(Argelia). En cualquier caso, la comparación de los valores medios de densidad también debe considerarse con cautela, intentando evaluar la representatividad de los datos en cada localidad.

La distribución de tallas de *P. ferruginea* en el litoral de Melilla está bien estructurada, estando presentes tanto juveniles de pequeño tamaño como adultos de un amplio rango de tallas. La presencia de juveniles y de adultos en un amplio rango de tallas ha sido descrita para otras localidades con poblaciones de *P. ferruginea* que se consideran en buen estado, como Ceuta (Espinosa *et al.*, 2009; Rivera-Ingraham *et al.*, 2011), las islas Habibas (Boumaza y Semroud, 2011; Espinosa, 2009) y las islas Chafarinas (Aparici-Seguer *et al.*, 1995, Guallart *et al.*, 2006). Frente a estas se halla la población de la isla de Alborán, que se ha mantenido estable durante los últimos años, pero en la que la mayor parte de los ejemplares censados son adultos de talla mediana o grande, con una presencia mínima de juveniles de pequeño tamaño (Paracuellos *et al.*, 2003; Barba *et al.*, 2006; Arroyo *et al.*, 2011). Este último dato puede indicar un estado poco "saludable" de la población de Alborán, con un reclutamiento bajo y posiblemente dependiente de la eventual llegada de larvas desde poblaciones externas.

Otros aspectos que han sido utilizados para evaluar el estado de las poblaciones de *P. ferruginea*, y de otras especies de lapas de gran tamaño sobre las que existe presión humana, han sido la talla máxima y la talla media de los ejemplares censados en diferentes localidades. En general, los estudios realizados muestran que en las zonas más accesibles o donde la captura de lapas es un hecho frecuente, la talla máxima y la talla media de los ejemplares de cada población tiende a disminuir, porque las capturas tienden a centrarse en los ejemplares de mayor tamaño (Pombo y Escofet, 1996; Branch y Odendaal, 2003; Kido y Murray, 2003; Sagarin, Ambrose, Bonnie, Engle, Kido, Lee, Miner, Murray, Raimondi, Richards y Roe, 2007; Espinosa, Rivera-Ingraham, Fa y García-Gómez, 2009). Sin embargo, hay otros factores que pueden influir en estos parámetros independientemente de la acción humana, como las diferencias en las características del hábitat, el grado de exposición al hidrodinamismo o la interacción con otras especies (Lewis y Bowman, 1975; Fletcher, 1984; Branch y Odendaal, 2003).

En el presente estudio, el mayor ejemplar medido en el litoral de Melilla alcanzó 84,2 mm, mientras que González-García *et al.* (2006) citaron en esta zona un ejemplar de 88,0 mm. Estas dimensiones se hallan lejos del tamaño máximo citado para la especie, 103 mm de un ejemplar de la colección Dautzenberg del Museo de Historia Natural de Bruselas (Christiaens, 1973) o 105 mm en ejemplares vivos medidos en el medio natural, en la isla de Alborán (Barba *et al.*, 2006) y en Ceuta (Espinosa *et al.*, 2009). La presencia de ejemplares de DM> 90 mm, aunque con una frecuencia a menudo moderada o baja, ha sido citada en las islas Chafarinas (Aparici-Seguer *et al.*, 1995; Guallart *et al.*, 2006), la isla de Alborán (Paracuellos *et al.*, 2003; Barba *et al.*, 2007), Ceuta (Espinosa *et al.*, 2009; Rivera-Ingraham *et al.*, 2011a) y las islas Habibas (Boumaza y Semroud, 2001; Espinosa, 2009). En la Tabla VI se resumen algunos ejemplos de tallas máxima y media de *P. ferruginea* en diferentes localidades. Siguiendo la argumentación de párrafos anteriores, consideramos que la talla media con fines comparativos no debe establecerse para la totalidad de ejemplares de una población, sino excluyendo a los ejemplares juveniles, dada su elevada variabilidad temporal y, por lo tanto, su influencia en el valor medio de la talla.

La talla media de los adultos (Tabla VI) hallada en Melilla (47,8 mm) es similar a la observada en Ceuta (47,9) y en las islas Chafarinas (53,8), y algo inferior a la de las islas Habibas (61,1), pero se halla muy por debajo de la observada en la isla de Alborán (71,4 mm). La elevada talla media de la población de Alborán, estimada en 540 ejemplares en 2010, con solamente un 1,5% de juveni-

Tabla VI. Rangos de talla máxima y media (± desviación estándar) de *P. ferruginea* para el contingente de población de DM> 30 mm (adultos) registrado en censos realizados en transecto en diversas localidades. Los números seguidos de asterisco indican que la talla media de los adultos se ha calculado a partir de las gráficas que aparecen en cada publicación. Excepto en el presente estudio, la talla media de los adultos se ha calculado asignando al número de los ejemplares de cada intervalo el valor medio de la talla.

Table VI. Ranges of maximum and average (± standard deviation) sizes of Patella ferruginea *for the population contingent of DM> 30 mm (adults) registered in different localities from censuses in transects. Numbers followed by an asterisk indicate that the average size of adults has been calculated from the published graphs. Except for the present study, the average size has been calculated assigning to the number of individuals of each interval the average size value.*

Zona	Referencia	Rango talla máxima (mm)	Talla media (mm) (sólo ejemplares DM> 30 mm)
Córcega	LABOREL-DEGUEN Y LABOREL (1991)	60-70	45,9 ± 10,3*
Zembra (Túnez)	TLIG-ZOUARI, RABAOUI, FGUIRI Y BEN HASSINE (2010)	85-90	63,1 ± 15,6*
Isla de Alborán	BARBA *ET AL.* (2006)	100-110	78,9 ± 18,7*
Algeciras y Gibraltar	ESPINOSA *ET AL.* (2005)	90-100	51,9 ± 11,8*
Cala Iris (Marruecos)	BAZAÏRI, SALVATI, BENHISSOUME, TUNESI, RAIS, AGNESI, BENHAMZA, FRANZOSINI, LIMAM, MO, MOLINARI, NACHITE Y SADKI (2004)	80-90	60,0 ± 14,4*
Islas Habibas (Argelia)	ESPINOSA (2009)	90-100	61,1 ± 12,7*
Isla Plana (Argelia)	ESPINOSA (2009)	70-80	41,9 ± 9,8*
Ceuta	RIVERA-INGRAHAM *ET AL.* (2011a)	100-110	47,9 ± 13,2*
Islas Chafarinas	APARICI-SEGUER *ET AL.* (1995)	90-100	53,8 ± 13,3*

les de DM< 30 mm (ARROYO *ET AL.*, 2011), podría deberse a que se trate de una población envejecida, resultante del éxito de reclutamientos puntuales, pero con escasa renovación de la población, como se ha comentado anteriormente. Por el contrario, la talla media relativamente baja en las islas Chafarinas, Ceuta y Melilla, podría indicar una renovación constante de la población y una relativamente baja supervivencia de los ejemplares más viejos. Los factores naturales y humanos que podrían determinar estos valores de talla media merecen una atención prioritaria en futuros estudios.

En este trabajo no se ha analizado el efecto de la presión humana por recolección sobre la población de Melilla, ya que se carece de datos concretos. Se han hallado, sin embargo, densidades altas en zonas muy frecuentadas por pescadores deportivos, como la escollera exterior del puerto, y entre moderadas y altas en el sector G, frecuentado por bañistas y pescadores deportivos. La presión por recolección de ejemplares sobre *P. ferruginea*, una de las principales causas a la que se ha atribuido la regresión de la especie (TEMPLADO, 2001; PARACUELLOS *ET AL.*, 2003; MORENO Y ARROYO, 2008; ESPINOSA *ET AL.*, 2009), debería también contemplarse como una de las líneas prioritarias de estudio en Melilla en el futuro. La existencia en su litoral de una zona en la que esta especie está bien representada y en la que la presión humana está controlada, como es el sector H (LIC de los Acantilados de Aguadú), puede contribuir a facilitar este estudio, ya que posibilita comparar su evolución con la de otras zonas próximas mucho más accesibles.

De acuerdo con los resultados obtenidos, la población de *Patella ferruginea* en el litoral de Melilla (32.821 adultos) sería la segunda en importancia en las costas españolas en cuanto a adultos, tras la

población de Chafarinas, cifrada en 42.320 ejemplares adultos (Guallart *et al.*, 2006), seguida por la de Ceuta (28.590 adultos, calculados a partir de los datos de Rivera-Ingraham *et al.*, 2011a). Las demás poblaciones conocidas en territorio español son mucho más reducidas, con unos pocos centenares de ejemplares en la bahía de Algeciras y Gibraltar (Espinosa *et al.*, 2005), la isla de Alborán (Paracuellos *et al.*, 2003; Barba *et al.*, 2006, Moreno *et al.*, 2008, Arroyo *et al.*, 2011), y pequeños grupos de ejemplares dispersos en el litoral andaluz (Arroyo *et al.*, 2011) y las islas Hormigas (Espinosa *et al.*, 2009).

Melilla es, pues, uno de los escasos lugares en los que todavía existe una importante población de esta lapa amenazada, por lo que debe considerarse un área crítica cuya correcta gestión es esencial para la supervivencia y la recuperación de la especie. Ello debería estimular a las autoridades medioambientales de la Ciudad Autónoma a elaborar lo antes posible un plan de recuperación para esta especie.

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Beak measurements of the Atlantic bobtail squid *Sepiola atlantica* (Cephalopoda: Sepiolidae): appropriate predictors of its body size and weight

Dimensiones de las mandíbulas de la sepiola del Atlántico *Sepiola atlantica* (Cephalopoda: Sepiolidae): indicadores apropiados de su tamaño y peso

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ABSTRACT

This work provides the relationships between nine mandible (beak) measurements and dorsal mantle length (ML), body mass (BW) and sex of 101 specimens (22 juveniles, 35 females, 44 males) of the Atlantic bobtail squid *Sepiola atlantica* from the Ría de Vigo (Galician waters, NW Spain). No significant differences were found between male and female beak measurements with discriminant analysis. Using linear regression analysis for grouped males and females it was found that some parts of the beaks grew isometrically whereas others grew asymetrically. Likely reasons of these discrepancies are discussed. It was shown that lower rostral length and upper rostral length were the parameters that best predict ML and/or BW of *S. atlantica* when using the full dataset (juveniles + males + females).

RESUMEN

Este trabajo proporciona las relaciones entre nueve medidas de las mandíbulas (picos) y la longitud dorsal del manto (ML), masa corporal (BW) y sexo de 101 especímenes (22 juveniles, 35 hembras y 44 machos) del sepiólido *Sepiola atlantica* provenientes de la Ría de Vigo (Galicia, NO de España). No se detectaron diferencias significativas entre las dimensiones del pico de machos y hembras mediante análisis discriminante. Al utilizar regresiones lineales para analizar machos y hembras conjuntamente se verificó que unas partes de los picos crecieron isométricamente mientras otras alometricamente. Se discuten los posibles motivos de estas discrepancias. Se demostró que longitud rostral de la mandíbula inferior y la longitud del rostro de la superior son los parámetros que mejor predicen la ML o la BW de *S. atlantica* cuando se utilizó el conjunto de datos completo (juveniles + machos + hembras).

INTRODUCTION

The members of the family Sepiolidae, commonly known as bobtail squids, are represented in tropical, temperate and sub polar waters of all oceans (Reid and Jereb, 2005). The Atlantic bobtail squid *Sepiola atlantica* d Orbigny, 1840 is widely distributed in the North-eastern Atlantic from latitudes 65°N to 35°N

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(Reid and Jereb, 2005), and it is a nekto-benthic relatively abundant species along its range of distribution (Jones and Richardson, 2012; Rodrigues, Garcí, Troncoso and Guerra, 2011a).

S. atlantica plays a role as both prey and predator in marine ecosystems. As prey it has been found in the stomach contents of several cephalopod species (Castro and Guerra, 1990; Blanc, Pinczon du Sel and Daguzan, 1998), fish (Patterson, 1985; Velasco, Olaso and Sánchez, 2001; Mahe, Amara, Bryckaert, Kacher and Brylinski, 2007) and top predators like marine mammals (Silva, 1999; Pierrepont, Dubois and Desormonts, 2005). As predator, *S. atlantica* eats small fish (Rodrigues, Troncoso, Garcí and Guerra, 2011b), mysid shrimp (Yau and Boyle, 1996; Jones and Richardson, 2010; Rodrigues *et al.*, 2011b; Rodrigues, Guerra and Troncoso, 2011c) and amphipods (Yau and Boyle, 1996). Cephalopod mandibles or "beaks" are hard structures composed of chitin-protein complexes (Hunt and Nixon, 1981), which resist digestion, and can accumulate in the stomachs of predators (Clarke, 1986). Cephalopod beak morphometry is a useful tool for taxonomy (Clarke, 1962; 1986; Pérez-Gándaras, 1983). Some parameters of these structures show accurate relationship with size and body mass of the animal and can also be used for estimating the size of consumed cephalopods as well as assessing trophic interactions and predator-prey relations (Clarke, 1996; Bello, 1996; Staudinger, Juanes and Carlson, 2009; Petri , Ferri, Škeljo and Krustulovi Šifner, 2010). This is essential for biomass calculations (Pérez-Gándaras, 1983; Clarke, 1986; 1987).

Although the beak morphology has been described for *S. atlantica* (Pérez-Gandáras 1983, Guerra 1986), this work aims to provide a better understanding of the relationship between beak measurements, body size, body mass and sex using a complete dataset, which comprises a wide size range and all the maturity stages of the species.

MATERIAL AND METHODS

A total of 101 specimens (22 juveniles, 35 females, 44 males) have been examined. Samples were obtained in several dives carried out in the Ría of Vigo (42°14` N; 8°47` W - NW Iberian Peninsula) between November 2007 and December 2009. Depth of collection ranged from 4 to 8 meters. The seabed was sandy, without seaweed, and with presence of ripplemarks.

Living bobtail squids were transported to the Marine Station of the University of Vigo at Toralla Island (ECIMAT) where the current study was mainly undertaken. In the laboratory, all specimens were anesthetized in a 1:1 mixture of artificial sea water and 7.14% MgCl2 (Messenger, 1985). Dorsal mantle length (ML), and body mass (BW) were immediately measured to 0.001 mm and 0.01 g accuracy, respectively. Specimens were also sexed following Rodrigues, Guerra and Troncoso (2012). Beaks were carefully removed and analysed within 0.001 mm accuracy under a Nikon SMZ-1500 stereomicroscope directly connected to a computer with image analysis software (Nikon, NIS-Elements, Tokyo, Japan). All beak measurements were made on preserved (70% ethanol) specimens. Four measurements from the upper beaks (UB) and five from lower beaks (LB) for all males and females were obtained according to the nomenclature of Clarke (1962, 1986) and Pérez-Gándaras (1983) (Figure 1). Measurements recorded from UB were: upper rostral length (URL), upper hood length (UHL), upper crest length (UCL), and upper hood height (UHH). For the LB the following measurements were recorded: lower rostral length (LRL), lower hood length (LHL), lower crest length (LCL), lower hood height (LHH) and lower baseline length (LBL). In juveniles, only URL and LRL were measured, because beaks were very soft and broke easily.

Relationships between each beak measurement and the corresponding individual ML or BW were calculated using linear regressions. All data were

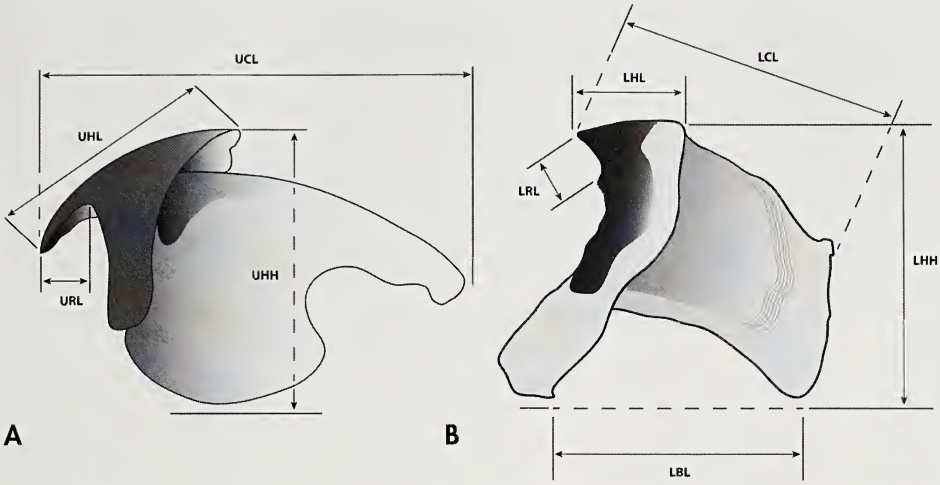

Figure 1. Beak measurements for *Sepiola atlantica*. A. Upper beak: upper rostral length (URL), upper hood length (UHL), upper crest length (UCL), and upper hood height (UHH); B. Lower beak: lower rostral length (LRL), lower hood length (LHL), lower crest length (LCL), lower hood height (LHH) and lower baseline length (LBL).

Figura 1. Medidas de las mandíbulas de Sepiola atlantica. *A. Mandíbula superior: longitud rostral superior (URL), longitud del capuchón superior (UHL), longitud de la cresta superior (UCL), y altura del capuchón superior (UHH); B. Mandíbula inferior: longitud rostral inferior (LRL), longitud del capuchón inferior (LHL), longitud de la cresta inferior (LCL), altura del capuchón inferior (LHH), y longitud de la línea base del pico inferior (LBL).*

previously transformed using decimal logarithms (ln). This analysis allowed calculating the relative growth rate ("b") using minimum squares (RICKER, 1973). Values of b > 1 indicate positive allometry, b < 1 negative allometry, and b = 1 isometry in the length-length relationships. Isometric growth is expressed for b = 3 in the length-weight relationships (RICKER, 1973). To verify whether UB and LB differ between sexes, a discriminate analysis was carried out using all morphological variables for sexed specimens. All analyses were undertaken with the IBM SPSS® 19 Statistics package.

RESULTS

The 101 measured specimens of *Sepiola atlantica* fall within the three ML classes that covered a wide size range and all maturity stages of this species. ML ranges for each class are shown in Table I. Upper and lower beak morphology coincides with the one described by CLARKE (1962; 1980) for members of the family Sepiolidae, and matches the characters provided by PÉREZ-GÁNDARAS (1983) for *S. atlantica* specimens.

Ratios and main characteristics for lower and upper beaks of the species are as follows:

Lower beak (LB)

LRL ≤ 0.7 mm; Ratios: LCL/LHL= 2.09; LHL/LRL=1.61; LRL/LWL=0.72; LCL/LWL=2.29, where LCL: lower crest length; LHL: lower hood length; LRL: lower rostral length; LWL: lower wing length. Other characteristics: i) the lower beak lacks rostral hood; ii) the distance between the crest and the hood is moderate; III) the crest profile is slightly curved; iv) the wing has no lateral fold; v) the posterior and external border of the hood present a broad and shallow recess; vi) the hood surface is smooth; vii) the external border of the wing is

Table I. *Sepiola atlantica.* Range of measurements (minimum - maximum) for each studied class. BW: Body weight (g), ML: dorsal mantle length (mm), URL: upper rostral length (mm), UHL: upper hood length (mm), UCL: upper crest length (mm), UHH: upper hood height (mm), LHL: lower hood length (mm), LRL: lower rostral length, LCL: lower crest length (mm), LHH: lower hood height (mm), LBL: lower baseline length (mm).
Tabla I. Sepiola atlantica. *Rango de medidas (mínimo - máximo) en cada clase estudiada. BW: peso corporal (g), ML: longitud dorsal del manto (mm), URL: longitud rostral superior (mm), UHL: longitud del capuchón superior (mm), UCL: longitud de la cresta superior (mm), UHH: altura del capuchón superior (mm), LRL: longitud rostral inferior (mm), LHL: longitud del capuchón inferior (mm), LCL: longitud de la cresta inferior (mm), LHH: altura del capuchón inferior (mm), LBL: longitud de la línea base del pico inferior (mm).*

Class	n	ML	BW	URL	UHL	UCL
Juveniles	22	2.70-4.63	0.01-0.11	0.14-0.34	-	-
Females	35	4.22-18.31	0.08-2.39	0.21-0.69	1.05-2.33	1.21-4.23
Males	44	3.87-14.44	0.05-1.97	0.28-0.71	0.92-2.10	1.82-3.92
Class	**UHH**	**LRL**	**LHL**	**LCL**	**LHH**	**LBL**
Juveniles	-	0.07-0.33	-	-	-	-
Females	0.85-2.86	0.22-0.71	0.33-1.11	0.84-2.31	0.66-2.49	0.80-2.35
Males	0.47-2.41	0.19-0.54	0.39-1.03	1.01-1.96	0.75-1.93	0.97-2.05

Table II. *Sepiola atlantica.* Discriminant analysis for sex effect on the upper and lower beak measurements.
Tabla II. Sepiola atlantica. *Análisis discriminante entre el sexo y las medidas de las mandíbulas superior e inferior.*

Sample	Variables	Effect	Wilks lambda	df 1	df 2	p
Both sexes	Upper Beak	1	0.74	4	79	0.056
Both sexes	Lower Beak	1	0.86	5	79	0.102

low, barely concealing the mandible angle profile; viii) the shoulder forms a long crest with an intermediate cartilaginous layer present; ix) wing with radiate streaks from the shoulder; and x) rostral border formed as a jagged thin sheet.

Upper beak

Ratios: UCL/UHL=1.80; UHL/URL= 3.58; URL/UWL=0.64; UCL/UWL=4.33; where UCL: upper crest length; UHL: upper hood length; URL: upper rostral length; UWL: upper wing length. Other characteristics: i) the distance between the crest and the hood is very short; ii) the palate has two small lateral grooves, no ribs; iii) the mandible angle is almost 90°; and iv) rostral border is formed as a jagged thin sheet.

Results of the discriminant analysis showed that UB and LB characteristics were not significantly different between males and females (Table II). This analysis also showed that UB and LB growth depends only on ML and BW. Since no significant differences were detected between sexes, both sexes were considered together for further analysis.

Linear computed regressions for grouped males and females revealed a significant relationship ($p<0.001$) between all beak measurements and ML or BW. However, the relationship

Table III. *Sepiola atlantica*. Linear regression equations between the dorsal mantle length (ML) or body mass (BW) and beak measurements for grouped male and female individuals. LRL: lower rostral length, LHL: lower hood length, LCL: lower crest length, LHH: lower hood height, LBL: lower baseline length, URL: upper rostral length, UHL: upper hood length, UCL: upper crest length, UHH: upper hood height.
Tabla III. Sepiola atlantica. *Regresión lineal entre la longitud dorsal del manto (ML), o la masa corporal (BW), y medidas de las mandíbulas para machos y hembras agrupados. LRL: longitud rostral inferior, LHL: longitud del capuchón inferior, LCL: longitud de la cresta inferior, LHH: altura del capuchón inferior, LBL: longitud de la línea base del pico inferior, URL: longitud rostral superior, UHL: longitud del capuchón superior, UCL: longitud de la cresta superior, UHH: altura del capuchón superior.*

Regression equations	n	Regression coefficient	Standard error (b)	r^2	F	p
Lower beak						
Ln BW = 1.486 + 2.147 LnLRL	79	0.73	0.23	0.53	88.14	0.001
Ln BW = 0.525 + 2.568 LnLHL	79	0.81	0.21	0.66	148.94	0.001
Ln BW = -1.762 + 3.074 LnLCL	79	0.84	0.23	0.70	181.76	0.001
Ln BW = -1.209 + 1.990 LnLBL	79	0.65	0.27	0.42	56.17	0.001
Ln BW = -1.723 + 2.937 LnLHH	79	0.84	0.22	0.71	183.97	0.001
Ln ML = 3.173 + 0.974 LnLRL	79	0.73	0.11	0.53	86.86	0.001
Ln ML = 2.744 + 1.183 LnLHL	79	0.82	0.09	0.68	159.69	0.001
Ln ML = 1.700 + 1.392 LnLCL	79	0.83	0.11	0.70	175.48	0.001
Ln ML = 1.945 + 0.919 LnLBL	79	0.66	0.12	0.43	59.07	0.001
Ln ML = 1.334 + 1.716 LnLHH	79	0.84	0.10	0.70	181.39	0.001
Upper beak						
Ln BW = 1.590 + 2.734 LnURL	79	0.81	0.23	0.66	146.68	0.001
Ln BW = -1.725 + 2.979 LnUHL	79	0.78	0.27	0.61	121.68	0.001
Ln BW = -3.167 + 2.618 LnUCL	79	0.75	0.26	0.57	100.74	0.001
Ln BW = -1.515 + 1.961 LnUHH	79	0.72	0.22	0.51	81.22	0.001
Ln ML = 1.223 + 3.206 LnURL	79	0.80	0.11	0.63	132.97	0.001
Ln ML = 1.708 + 1.371 LnUHL	79	0.79	0.12	0.63	128.83	0.001
Ln ML = 1.038 + 1.211 LnUCL	79	0.77	0.12	0.59	108.67	0.001
Ln ML = 1.788 + 0.937 LnUHH	79	0.75	0.09	0.57	100.25	0.001

between BW and Lower Baseline Length (Table III) showed the lowest coefficient of correlation (r^2 < 50%). The best LB measurement predictor to BW and ML was the Lower Hood Height, while in the UB it was the Upper Rostral Length for both ML and BW (Table III).

The equations shown in Table III display different relationships between variables. The shape of the LB showed a practically isometric growth in relation to BW, this is the case of the Lower Crest Length and the Lower Hood Height; however it was weakly isometric or negative allometric for Lower Rostral Length and Lower Hood Length. In the case of LBL *vs* BW a clear negative allometric was found. All UB measures, except Upper Hood Height -that was negative allometric-, showed a weak negative allometric growth.

Regressions between the nine beak variables *vs* ML showed isometric growth except of LRL, LBL and UHH, although they were very close to an isometric growth pattern. On the other hand, LHH was the beak variable that shows faster growing when fitted against ML. Alternatively, URL was the faster growing UB parameter in respect to ML (Table III).

When all specimens (juveniles + males + females) were pooled together, URL_{all} and LRL_{all} showed a significant

Table IV. *Sepiola atlantica*. Linear regression equations between the dorsal mantle length (ML) or body mass (BW) and two beak measurements for grouped juvenile, male and female individuals. LRL: lower rostral length, and URL: upper rostral length.
Tabla IV. Sepiola atlantica. *Regresiones lineales entre la longitud dorsal del manto (ML), o la masa corporal (BW), y dos medidas de las mandíbulas para juveniles, machos y hembras agrupados. LRL: longitud rostral inferior, y URL: longitud rostral superior.*

Regression equations	n	Regression coefficient	Standard error (b)	r^2	F	*p*
Lower beak						
Ln BW = 1.404 + 2.108 LnLRLall	101	0.86	0.13	0.74	285.94	0.001
Ln ML = 3.060 + 0.865 LnLRLall	101	0.86	0.05	0.73	271.44	0.001
Upper beak						
Ln BW = 2.034 + 3.448 LnURLall	101	0.88	0.19	0.78	343.93	0.001
Ln ML = 3.324 + 1.422 LnURLall	101	0.88	0.08	0.77	337.02	0.001

relationship with both ML and BW ($p<0.001$) with higher regression coefficient score (Table IV) than the ones computed for males and females together (Table III). The relationships between URLall and BW or ML explained up to 78% (r^2) and were positively allometric. Otherwise, LRLall showed negative allometry when plotted against both ML and BW.

DISCUSSION

The studies carried out with *S. atlantica* from the Ría de Vigo have provided new insights on several aspects of its life cycle and ecology (see Rodrigues *et al.*, 2012; 2011a; b; c). With whole-body and fresh specimens provided by sampling dives during these studies it was easy to identify the species using previous works (e.g. Guerra, 1986; Bello, 1995; De Heij and Goud, 2010). However, it is actually difficult to distinguish between the different *Sepiola* species only from their beaks (Pérez-Gándaras, 1983; Clarke, 1980). In the case of wanting to identify species from the stomach content of any of their potential predators, beside size and characteristics of the beaks, the geographical distribution of the species in question as well as of the predator are both helpful hints (Clarke 1980). The shape and measurements given herein for beaks of *S. atlantica* agree with those provided by Guerra (1986) and Pérez-Gándaras (1983). They are also quite similar to other bobtail squids (Pérez-Gándaras, 1983; Lu and Ickeringil, 2002; Açik and Salman, 2010). Our result that there is no significant difference between beak morphology of males and females of *S. atlantica* also agree with previous analysis by Pérez-Gándaras (1983) for the same species in Galician waters (NW Spain).

Growth rates of cephalopods, including hard structures, can be strongly influenced by environmental changes, as well as by availability and type of food (Pierce *et al.*, 2008). Considering that we analysed a *S. atlantica* population within a small and uniform ecosystem, the absence of differences in beak shape could be due to exposure to the same abiotic and biotic conditions. However, these morphometric analyses using beak measurements could be different if they were undertaken with specimens covering the whole range of distribution of the species. Thus, geographic intraspecific variations were found in other species (Boyle and Ngoile, 1993; Pierce *et al.*, 1994; Rocha and Guerra, 1999; Petric *et al.*, 2010), and between seasonal spawning groups (Kashiwada, Recksiek and Karpov, 1979), as well as intraspecific

variation due to growth and sexual dimorphism (BELLO, 2001).

Beak biometric relationships have been examined in species of the three Sepiolidae subfamilies (Sepiolinae, Rossinae and Heteroteuthinae) showing that they are a good predictor of ML and BW (PÉREZ-GÁNDARAS, 1983; CLARKE, 1986; LU AND ICKERINGIL, 2002; AÇIK AND SALMAN, 2010). Unfortunately, the data available in the literature for relationships between beak parameters and ML were obtained without log transformed measurements, which precludes suitable comparisons with our results. However, the aforementioned works provided comparisons between beak parameters and BW using log transformed data. The slopes of the equations obtained for BW were similar those obtained for *S. atlantica* in the present paper. Allometric conditions were discrepant when comparing male and female variables, as is the case of BW and/or ML *vs* URL (Table III) showing a negative and positive allometry condition, respectively. Alternatively, when using our full dataset that covers the five maturity stages proposed for *S. atlantica* (RODRIGUES *ET AL.*, 2012) the agreement of allometry conditions between ML and BW was obtained (Table IV). The implications of this interaction are difficult to resolve since sex was found to have no significant effect by itself. In consequence, factors other than body size, weight or sex have major effects on the beak s growth during the lifetime of *S. atlantica*, and one of these factors might be sexual maturation, as shown by KASHIWADA *ET AL.* (1979) in the squid *Loligo opalescens* and STAUDINGER *ET AL.* (2009) for *Loligo pealeii* and *Illex illecebrosus*. Nevertheless, it must be born in mind that some of the allometry found could be due to the inaccuracy of the beak parameter measurements. In this regard, the LHH and UHH (Fig. 1) can be very inaccurately measured due to beak deformations.

The results presented here are the most comprehensive dataset on the shape and morphometrics of *S. atlantica* beaks to date. The present data can successfully be used as a predictor of ML and/or BW of the species, especially LRL_{all} and URL_{all} (Table IV). Since quantification of predator-prey body size relationships are crucial to understand trophic dynamics in marine ecosystems, the results of the present study are intended to help quantitative assessments of *S. atlantica* prey in the diets of its predators.

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Consideraciones nomenclaturales sobre las especies del género *Allognathus* (Gastropoda: Pulmonata: Helicidae) y estudio anatómico de *Allognathus hispanicus tanitianus*

Nomenclatural considerations about *Allognathus* species (Gastropoda: Pulmonata: Helicidae) and anatomical study of *Allognathus hispanicus tanitianus*

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RESUMEN

En el presente trabajo se hace una revisión nomenclatural para las especies del género *Allognathus* Pilsbry, 1888, endémico del Archipiélago Balear (España), en particular de *Allognathus (Allognathus) grateloupi*, *A. (Iberellus) hispanicus* y *A. (I.) hispanicus campanyonii*. Además, se redescribe la anatomía del aparato reproductor de *A. (I.) hispanicus tanitianus* (Forés & Vilella, 1993) cuya descripción original incluye algunos datos que, en nuestra opinión, no representan con exactitud su morfología.

ABSTRACT

A nomenclatural revision of the species of the genus *Allognathus* Pilsbry, 1888, endemic of the Balearic Islands (Spain) is conducted in the present work. Particular mention is given to *Allognathus (Allognathus) grateloupi*, *A. (Iberellus) hispanicus* and *A. (I.) hispanicus campanyonii*. Furthermore, we include a redescription of the reproductive apparatus of *A. (I.) hispanicus tanitianus* (Forés & Vilella, 1993) as the original description does not represent accurately, in our opinion, the morphology of the reproductive apparatus.

INTRODUCCIÓN

Allognathus Pilsbry, 1888, es un género originalmente endémico del archipiélago Balear, que se encuentra presente en todas las islas principales y en varios de sus islotes periféricos (Gasull, 1963; Beckmann, 2007). Debido a su gran variabilidad conquiológica y al aislamiento geográfico, se han descrito hasta 9 taxones nominales para el género. Uno de estos taxones también ha sido citado en Cataluña y sur de Francia, en las localidades de

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Tabla I. Clasificaciones propuestas para el género *Allognathus* s.l. durante la primera década del s. XXI.
Table I. Classifications proposed for the genus Allognathus *s.l. during the first decade of XXI century.*

Bank, 2010	Beckmann, 2007	Schileyko, 2006
Allognathus (A.) graellsianus	*Allognathus (A.) graellsianus*	*Allognathus grateloupi*
Allognathus (Iberellus) hispanicus	*Allognathus (Iberellus) balearicus*	*Iberellus balearica*
Allognathus (Iberellus) pyrenaicus		*I. pyrenaicus*
A. (I.) p. horadadae	*A. (I.) b. horadadae*	*I. horadadae*
A. (I.) p. minoricensis	*A. (I.) b. minoricensis*	
A. (I.) p. palumbariae		
A. (I.) p. tanitianus	*A. (I.) b. tanitianus*	
A. (I.) p. pythiusensis	*A. (I.) b. pythiusensis*	*Nesiberus pythiusensis*

Banyuls sur Mer (Pirineos Orientales), en las ciudades de Barcelona, Sitges y Tarragona, siendo esta última localidad la única que alberga una población actualmente viva de la especie (Gasull, 1966; Altaba, 2007). Estas poblaciones peninsulares son atribuidas a introducciones antrópicas acaecidas en tiempos históricos (Sacchi, 1957; Gasull, 1963; Gasull, 1966).

Aún tratándose de un endemismo balear, la primera referencia a una especie del género, proviene de Banyuls sur Mer (Pirineos Orientales, Francia), bajo el nombre de *Helix Companyonii* Aleron in Companyo, 1837, aunque sin ir acompañada de descripción alguna (ver discusión nomenclatural). Rossmässler (1838) aporta la primera descripción para un taxón del género, *Helix hispanica* "Partsch" en cuya sinonimia incluye *H. balearica* Ziegler. Posteriormente, (Rossmässler, 1839) designa al taxón proveniente de Pirineos Orientales como *Helix hispanica* var. *pyrenaica*, en cuya sinonimia incluye *H. Campanyonii*. Por otra parte, Mittre (1842) describe *Helix Minoricensis* de la isla de Menorca. Graells (1846) describe *Helix Grateloupi* procedente de Mallorca, que más adelante Peiffer (1848) denominaría como *H. graellsiana*. Pilsbry (1888) crearía el género *Allognathus* para *H. Grateloupi* Graells 1846, mientras que Hesse (1908) erigiría el género *Iberellus* para el grupo de *Helix balearica* y *H. minoricensis*. *Iberellus* es un nombre sustituto para *Balearica* Kobelt, 1904, nombre preocupado por un taxón de aves. La especie tipo de *Allognathus* es *Helix grateloupi*, por designación original; *Iberellus* hereda la especie tipo de *Balearica*, que por lo tanto sería *Helix balearica* Rossmässler, 1838 por tautonimia absoluta.

Posteriormente, en la primera mitad del siglo XX, se describen varios nuevos taxones de reducida distribución: *Helix pythiusensis* Bofill & Aguilar-Amat, 1924, *Iberellus minoricensis palumbariae* Aguilar-Amat, 1933 e *Iberellus minoricensis horadadae* Jaeckel, 1952. Por último Forés & Vilella (1993), describen *Iberellus tanitianus*, endémico de la isla de Ibiza. Algunas de las principales clasificaciones propuestas para el conjunto de taxones pueden verse en la Tabla I.

La validez nomenclatural de *Iberellus campanyonii* ha sido tema de discusión desde su primera cita como *Helix companyonii* Aleron in Companyo 1837, y más recientemente en diversos trabajos (Forés, 2003; Alonso-Zarazaga, 2004; Altaba, 2007; Beckmann, 2007; Alba, Tarruella, Prats, Guillén y Corbella, 2011). Sin embargo creemos que las decisiones adoptadas en estos trabajos no son adecuadas en su totalidad. Del mismo modo, existen una serie de discrepancias en torno al empleo de los nombres *Iberellus hispanicus* e *I. balearicus*, por una parte, y de *Allognathus graellsianus* y *A. grateloupi*, por otra. Por ello hemos considerado oportuno realizar una revisión y proponer una nomenclatura acorde a las disposiciones del

Código Internacional de Nomenclatura Zoológica (CINZ).

Por último, las observaciones anatómicas que hemos llevado a cabo sobre ejemplares de *Allognathus (Iberellus) hispanicus tanitianus* (Forés & Vilella, 1993), nos han permitido constatar que la descripción original no representa con exactitud la morfología del aparato reproductor de esta especie, por lo que procedemos a su redescripción.

MATERIAL Y MÉTODOS

Para la discusión nomenclatural se ha procedido a consultar las obras originales con las descripciones y figuras aportadas para cada especie nominal.

La descripción de cada taxón está basada en el estudio del material relacionado en el Apéndice 1. En aquellos casos en que existe una localidad tipo para un taxón, se han incluido topotipos dentro del material analizado. Cuando no existe una localidad tipo concreta, se han analizado ejemplares procedentes del rango de distribución de cada taxón, habiendo confirmado su identificación con las descripciones originales y con obras que han tratado extensamente el género *Allognathus s.l.* (GASULL, 1963; 1966; BECKMAN, 2007; QUINTANA, 2007).

RESULTADOS Y DISCUSIÓN

1. Revisión nomenclatural de las especies del género *Allognathus*

La primera decisión a adoptar es la concerniente al estatus taxonómico de *Allognathus* e *Iberellus*, que son tratados, o bien como géneros diferentes (ALONSO-ZARAZAGA, 2004; SCHILEYKO, 2006; QUINTANA, 2007; ALTABA, 2007; ALBA *ET AL.*, 2011; WELTER-SCHULTES, 2012), o como subgéneros de *Allognathus* (BANK, BOUCHET, FALKNER, GITTENBERGER, HAUSDORF, PROSCHWITZ Y RIPKEN, 2001; BECKMANN, 2007). Personalmente nos decantamos por clasificar ambos taxones como subgéneros de *Allognathus*. Ello permite reflejar en la clasificación de los helicinos la estrecha relación filogenética existente entre ambos taxones, que consideramos grupos hermanos y, por tanto, más próximos entre sí que con respecto a otros géneros de helicinos (*Otala*, *Pseudotachea*, etc). Por otro lado, esta decisión es concordante con lo propuesto por la clasificación adoptada para los taxones supraespecíficos europeos por BANK *ET AL.* (2001). En lo concerniente a la clasificación del taxón de las islas Bledas en un género diferente (*Nesiberus* Haas 1934), no parece justificada ni por la morfología de la concha ni del aparato reproductor, en contra de la clasificación adoptada por SCHILEYKO (2006).

Helix hispanica Rossmässler, 1838

Algunos autores (SCHILEYKO, 2006; ALTABA, 2007; BECKMANN, 2007; QUINTANA, 2007) designan a este taxón como *Allognathus (Iberellus) balearicus*. La utilización de *H. balearica* como nombre válido es debida a un supuesto caso de homonimia de *H. hispanica* Rossmässler 1838 con el taxón *Helix lactea* var. *Hispanica* Potiez & Michaud, obra tradicionalmente fechada en 1835, lo que haría que el nombre dado por ROSSMÄSSLER (1838) no estuviese disponible. Sin embargo KADOLSKY (2012) determina fehacientemente que la obra de POTIEZ Y MICHAUD "Galerie des mollusques, ou catalogue méthodique, descriptif et raisonné des mollusques et coquilles du Muséum de Douai", se desarrolló entre los años 1835 y 1838, pero no hay pruebas de que las partes impresas se encontrasen disponibles por compra o intercambio antes del 27 de Octubre de 1838. Esta es, por tanto, la fecha más antigua referente a la publicación del trabajo mencionado

(KADOLSKY, 2012). La obra de ROSSMÄSSLER (1838) data de Junio de 1838, lo que hace que el nombre *H. hispanica* de ROSSMÄSSLER (1838) tenga prioridad sobre el de POTIEZ Y MICHAUD (1838), en derivación *Allognathus (Iberellus) hispanicus*, quedando *Helix balearica* Rossmässler (1838) como un sinónimo del mismo, tal y como ROSSMÄSSLER (1838) propone en su obra original.

Helix campanyonii Anton in Rossmässler, 1839

El problema nomenclatural más controvertido es el referente a la validez del nombre *Allognathus (I.) campanyonii*. Algunos autores como FORÉS (2003); FORÉS (2004); ALBA *ET AL.* (2011), consideran que *Helix companyonii* Aleron in Companyo 1837 no sería un *nomen nudum* por lo que lo proponen como el primer nombre disponible válido que debería emplearse. *Helix companyonii*, fue citado por primera vez en el trabajo de COMPANYO (1837). En este trabajo se describe el contenido de un "cuadro expositor" realizado con conchas representativas de la malacofauna de Pirineos Orientales, que incluye ejemplares de esta especie, si bien no se realiza ninguna descripción, ya que la indicación de que "se parece" a *Helix serpentina* y *H. ondulata* no es un carácter diferencial. Además aquí se puede invocar a la negación de intención (CINZ art. 8.3) debido al uso de las palabras "nous pensons qu'elle n'a pas été décrite". Del mismo modo, la referencia de la especie en tal cuadro, podría entrar, en el caso de etiquetas en colección (CINZ art. 12.3). De acuerdo a estas disposiciones, el nombre *Helix companyonii* sería un *nomen nudum*, por lo que no estaría disponible referido a esta publicación.

Continuando con este problema nomenclatural, ALONSO-ZARAZAGA (2004), propone como nombre válido para este taxón *Helix hispanica* var. *pyrenaica* Rossmässler 1839, en combinación *Allognathus (Iberellus) pyrenaicus*. Sin embargo este nombre es un homónimo primario de *Helix pyrenaica* Draparnaud, 1805 (CINZ art. 57.2) (combinación original de *Norelona pyrenaica*). Ello nos lleva a descartar el uso de *A. (I.) pyrenaicus* (Rossmässler 1839), tal y como ha sido ya mencionado por otros autores (ALTABA, 2007; BECKMANN, 2007; ALBA *ET AL.*, 2011). En la misma publicación en la que se describe *Helix hispanica var. pyrenaica*, ROSSMÄSSLER (1839) sinonimiza *Helix Campanyonii* dentro de su nuevo taxón descrito. Este nombre publicado como sinónimo se hizo disponible (CINZ art. 11.6.1) ya que fue empleado como nombre válido antes de 1961 (VILLA Y VILLA, 1841; GRAELLS, 1846; MARTENS, 1864).

Algunos autores han considerado que en la obra de ROSSMÄSSLER (1839) hay una grafía original incorrecta (ALTABA, 2007; BECKMAN, 2007) por lo que proponen que debería realizarse una corrección del nombre de *campanyonii* a *companyonii* (CINZ art. 32.5.1). No obstante, no hay ninguna evidencia clara de que haya existido un error inadvertido en la publicación original, ya que ROSSMÄSSLER (1839) no indica en lugar alguno por qué eligió ese nombre. Por otro lado, WELTER-SCHULTES (2012) hace referencia al trabajo de ALBERS (1850), donde se menciona que ROSSMÄSSLER (1839) incluye en sinonimia a *H. Campanyonii* debido a una indicación de Hermann Eduard Anton en una carta en la cual dice que ha obtenido este caracol bajo el nombre *campanyonii* de Parreyss y que sospecha que el nombre se refiere a la localidad de "Campana, al pie de los Pirineos, cerca de Perpignan". Al no darse las condiciones para un error inadvertido, consideramos *Allognathus (Iberellus) campanyonii* (Rossmässler 1839) como nombre válido para este taxón, con la descripción y la lámina presentadas en ROSSMÄSSLER (1839).

Otra cuestión por dilucidar es la concerniente al número de taxones de *Iberellus* presentes en Mallorca. Algunos autores (BECKMANN, 2007; ALBA *ET AL.*; 2011) consideran que en Mallorca solo

vive una especie de *Iberellus*. En tal caso la especie debería denominarse *Allognathus (Iberellus) hispanicus*, conteniendo varias subespecies. Sin embargo, otros autores (FORÉS, 2003; ALTABA, 2007; QUINTANA, 2007; BANK, 2010) consideran que existen dos, *A. (I.) hispanicus* en la Sierra de la Tramuntana y *A. (I.) campanyonii* en las zonas bajas de la isla, y que sería esta última la especie introducida en Cataluña y sur de Francia (SACCHI, 1957; GASULL, 1963; GASULL, 1966). Estos dos taxones se corresponden con los descritos por ROSSMÄSSLER (1838; 1839), con sus respectivas láminas. Incluso hay autores que consideran que sólo hay una especie de *Iberellus* en todo el archipiélago Balear, sin distinción de subespecies. En la actualidad estamos realizando estudios moleculares basados en la secuenciación de ADN que esperamos permitan resolver la cuestión sobre el número de especies y subespecies presentes en el archipiélago Balear. Los resultados preliminares de estos estudios genéticos (datos no publicados) nos indican que *Iberellus* constituye una única especie según el concepto biológico de especie (DOBZHANSKY, 1937; MAYR, 1942).

Helix grateloupi Graells, 1846

Este taxón ha sido denominado tradicionalmente *Allognathus graellsianus* (Pfeiffer, 1848) (GASULL, 1966; PUENTE, 1994; BECKMANN, 2007; BANK, 2010), originalmente descrito en el binomen *Helix graellsiana*. Sin embargo, al igual que consideran otros autores (PILSBRY, 1888; SCHILEYKO, 2006; WELTER-SCHULTES, 2012), el nombre válido para esta especie es *Allognathus grateloupi*, originalmente descrito en el binomen *Helix grateloupi* Graells, 1846 y que tiene prioridad (CINZ art. 23) sobre *Helix graellsiana* Pfeiffer, 1848. BECKMANN (2007) considera *H. grateloupi* Graells, 1846 como *nomen nudum*, lo que es incorrecto, ya que dentro de la obra de GRAELLS (1846) se realiza una correcta descripción del nuevo taxón, acompañada de unas ilustraciones, con una mencionada intencionalidad de que se trata de una nueva especie, y a la que da el nombre de *H. grateloupi* dentro del apartado de "Correcciones y Adiciones" incorporado al final de dicha obra.

2. Estudio de la morfología del aparato reproductor de "*Iberellus tanitianus*" Forés & Vilella, 1993

La descripción de *Iberellus tanitianus* Forés & Vilella (1993) incluye una detallada descripción de concha, aparato reproductor, rádula y mandíbula. Las diferencias morfológicas encontradas, unidas a su aislamiento geográfico, permitieron a estos autores describir esta nueva especie de la isla de Ibiza. En la descripción original FORÉS Y VILELLA (1993) indican que los ejemplares de esta especie presentan un "pene de longitud mediana, con el epifalo casi dos veces y media más largo que él, configurado por una doble característica doble asa en forma de ocho". Además, el pene y el epifalo de *I. tanitianus* serían considerablemente más largos que en las otras especies del género (FORÉS Y VILELLA, 1993; QUINTANA, 2007) y, en proporción con el resto de órganos distales, más largos que en el resto de Helicinae. Sin embargo, los individuos de *Iberellus tanitianus* estudiados por nosotros no muestran epifalo y pene tan largos ni con esa forma característica representada en la descripción original.

Según lo observado en 8 ejemplares disecados de tres localidades, incluyendo ejemplares procedentes de las dos estudiadas por FORÉS Y VILELLA (1993), el aparato reproductor de *I. tanitianus* se caracterizaría (Fig. 1) por presentar un pene cilíndrico con un engrosamiento central. Epifalo cilíndrico más corto que la mitad del pene y más delgado que éste. Flagelo filiforme, casi

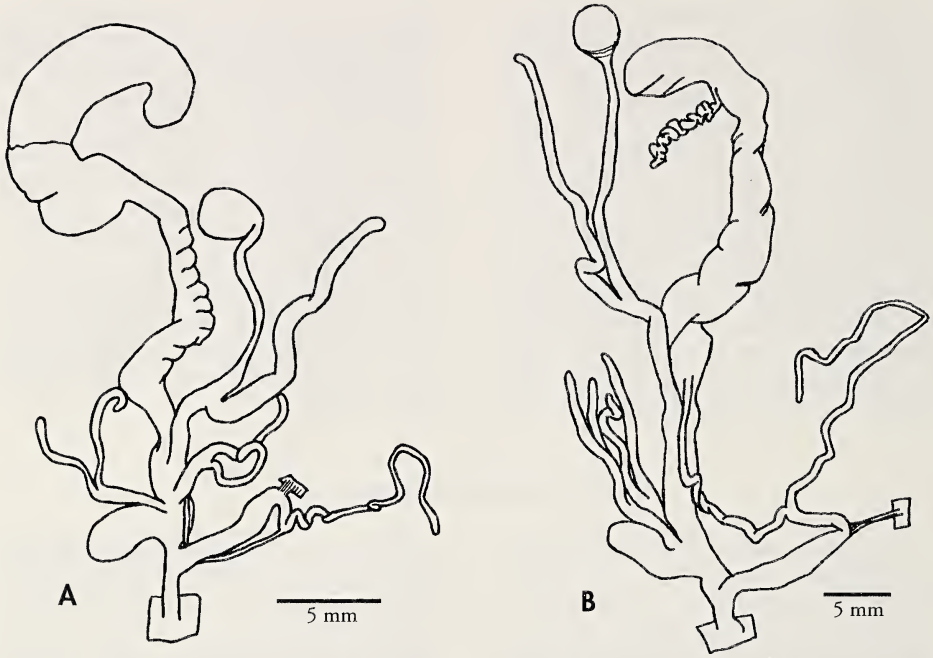

Figura 1. Aparato reproductor de *Allognathus (Iberellus) hispanicus tanitianus* (Forés y Vilella, 1993). A: Col de sa Creu (Ibiza); B: Cala Salada (Ibiza).
Figure 1. Reproductive apparatus of Allognathus (Iberellus) hispanicus tanitianus *(Forés y Vilella, 1993). A: Col de sa Creu (Ibiza); B: Cala Salada (Ibiza).*

el doble de largo que el conjunto de pene y epifalo. Vagina corta y gruesa sobre la que se inserta un saco del dardo grande y piriforme. Dos glándulas mucosas insertadas en la base del saco del dardo, estando ambas bifurcadas en su parte media (3-5 túbulos en cada glándula en los ejemplares de Cala Sant Vicenç). Bursa copulatrix grande y globosa con un conducto provisto de un divertículo. El divertículo es un 60% más largo que el conducto de la bursa. Oviducto libre corto.

La estructura de asa en forma de ocho representada en el trabajo de Forés y Vilella (1993) puede deberse, o bien al estudio de algún ejemplar teratológico, o a un error de interpretación del lugar de inserción del músculo retractor penial y del conducto deferente, ya que en todos los individuos analizados por nosotros, dichas estructuras se encuentran insertas en una posición similar al resto de especies del género (Puente, 1994; Quintana, 2007).

Taxonomía y descripción conquiológica

De acuerdo con la nueva información morfológica concerniente a la morfología del aparato reproductor de *Iberellus tanitianus* y tomando en consideración los comentarios nomenclaturales expuestos en este trabajo, proponemos la siguiente clasificación para el género *Allognathus*, en espera de que estudios genéticos actualmente en realización, junto a nuevos datos paleontológicos, nos permitan tener un conocimiento más exhaustivo de las relaciones filogenéticas de los taxones aquí considerados y de su historia evolutiva en el archipiélago Balear. Para cada taxón ofrecemos una breve diagnosis basada en la morfología de la concha y su distribución geográfica.

Género *Allognathus* Pilsbry 1888
Subgénero *Allognathus* Pilsbry 1888

Allognathus (Allognathus) grateloupi (Graells 1846)

Helix grateloupi Graells, 1846, *Catalog. Mol. España*: 3, Adiciones, Fig. 7-8 [Localidad tipo: Mallorca].
Helix graellsiana Pfeiffer, 1848, *Monogr. Helic. vivent.*, 1: 437-438 [Localidad tipo: Mallorca].

Concha globosa de paredes finas, frágil, con 4 a 4 ½ vueltas de crecimiento rápido. Última vuelta rápida y bruscamente descendente en la extremidad, bajando desde la tercera a la quinta banda espiral. Presenta 5 bandas espirales bien separadas, normalmente discontinuas. Boca ovalada-redonda con peristoma reflejado, coloreado de color pardo rojizo. Sin ombligo.

Distribución: NE Sierra de la Tramuntana (Mallorca).

Subgénero *Iberellus* Hesse 1908

Allognathus (Iberellus) hispanicus hispanicus (Rossmässler 1838)

Helix hispanica Rossmässler, 1838, *Icon.* 2 (1/2): 15, Fig. 460 [Localidad tipo: España].
Helix balearica Rossmässler, 1838, *Icon.* 2 (1/2): 15 (in syn).

Concha globosa-aplanada con 4 ½ vueltas muy planas pero dejando ver la sutura, estriación muy fina, irregular. Última vuelta unas tres veces más ancha que la penúltima, ensanchándose progresivamente hacia la boca. Abertura oblicua, ovalada, descendiendo ligeramente en la extremidad, bajando desde la tercera a la cuarta banda espiral. Peristoma sencillo con engrosamiento interno de color marrón y ligeramente reflejado. Ombligo cerrado. Callosidad columelar bien marcada.

Distribución: Sierra de la Tramuntana (Mallorca).

Allognathus (Iberellus) hispanicus campanyonii (Rossmässler 1839)

Helix Companyonii Aléron in Companyo, *Bull. Soc. Philomatique*, 3: 85-104 (*nomen nudum*).
Helix Campanyonii Rossmässler, 1839, *Icon.* 2 (3/4): 11 (in syn).
Helix hispanica var. *pyrenaica* Rossmässler, 1839, *Icon.* 2 (3/4): 11, Fig. 591 [Localidad tipo: Pirineos].
Helix oberndörferi Kobelt, 1882, *Nachr.-Bl. Dtsch. Malak. Ges.*, 14 (4/5): 69-70 [Localidad tipo: Palma, Mallorca].

Concha globosa de espira cónica poco elevada, 4 ½ a 5 vueltas convexas, marcando bien la sutura, la última doble ancha que la penúltima en las proximidades de la boca. Abertura ovalada, oblicua y descendente. Borde superior de la última vuelta fuerte y bruscamente descendente hacia la extremidad, bajando generalmente más allá de la cuarta banda espiral. Estriación muy fina y regular. Coloración dorsal generalmente marrón oscura, más clara por la parte ventral con las bandas espirales interrumpidas por flamulaciones dispuestas en zigzag, radiales y de color marfil. Peristoma ligeramente engrosado por su interior y algo reflejado, mostrando una callosidad en el borde columelar. Sin ombligo. Localmente (Archipiélago de Cabrera) las conchas son más sólidas, más pequeñas y con engrosamiento interno del peristoma más fuerte.

Distribución: Mallorca, introducida en Tarragona.

Allognathus (Iberellus) hispanicus minoricensis (Mittre 1842)

Helix Minoricensis Mittre, 1842, *Ann. Sci. Nat. (Zool.)*, (2) 18: 188 [Localidad tipo: Mahón, Menorca].

Concha con cinco bandas espirales marrones, más o menos continuas, aunque generalmente atravesadas por finas líneas radiales dispuestas en zigzag. La parte inferior de la concha siempre es más clara que la parte superior. Borde superior de la última vuelta fuerte y bruscamente descendente hacia la extremidad, bajando generalmente más allá de la cuarta banda espiral. Sin ombligo.

Dentro de este taxón encontramos una gran variedad en cuanto a la coloración y bandeado de la concha en diferentes poblaciones de la isla de Menorca (ver QUINTANA, 2007).

Distribución: Menorca, Ibiza y Formentera.

Allognathus (Iberellus) hispanicus palumbariae (Aguilar-Amat 1933)

Iberellus minoricensis palumbariae Aguilar-Amat, 1933, *Butll. Inst. catal. Hist. nat.*, 13 (6/7): 328 [Localidad tipo: Illa d'en Colom, Menorca].

Similar a *A. (I.) h. minoricensis*, del que se diferencia por tener una concha más sólida y por presentar un peristoma blanco, fuertemente engrosado y reflejado. Además las cinco bandas espirales se hacen mucho más oscuras en las proximidades de la abertura. Borde superior de la última vuelta fuerte y bruscamente descendente hacia la extremidad.

Distribución: Illa d'en Colom (Este de Menorca).

Allognathus (Iberellus) hispanicus horadadae (Jaeckel 1952)

Iberellus minoricensis horadadae Jaeckel, 1952, *Mitt. zool. Mus. Berlin*, 28: 84, 103, Abb. 6, Taf. 3 Fig. 1 [Localidad tipo: Isla Horadada].

Concha con 4 ½ vueltas. Color castaño, con las bandas espirales menos contrastadas respecto al color de fondo que en otras especies y difuminadas por las flamulaciones en zigzag. Ombligo imperforado.

Distribución: Illa Na Foradada (Archipiélago de Cabrera).

Allognathus (Iberellus) hispanicus tanitianus (Forés & Vilella 1993)

Iberellus tanitianus Forés & Vilella, 1993, *Bol. Soc. Hist. nat. Baleares*, 36: 17-29, Fig. 1, Fig, 2. [Localidad tipo, restr. nov.: Coll de sa Creu].

Concha globosa con la espira desde ligeramente convexa a cónica, de 3 ¼ a 3 ¾ vueltas. Sutura marcada. Peristoma bien reflejado, callosidad del borde columelar muy visible. Borde del peristoma blanco puro. Presenta, en general, pliegues junto a la sutura que desde el ápice descienden hacia la concha, claramente visibles a 30X. Boca oblicua y oval transversa. Estriación suave fina y bastante regular, con cinco bandas espirales en general continuas, finas y de color castaño claro. Flamulaciones radiales solo bien visibles entre la sutura y la primera banda espiral, más difuminadas en el resto de la concha. El color de fondo es córneo pálido. Ombligo imperforado. Borde superior de la última vuelta fuerte y bruscamente descendente hacia la extremidad.

Distribución: Ibiza.

Allognathus (Iberellus) hispanicus pythiusensis (Bofill & Aguilar-Amat 1924)

Helix (Archelix?) pythiusensis Bofill & Aguilar-Amat, 1924, *Trab. Mus. Cienc. nat.*, 10 (3): 27-28, Lam. 1 Fig. 10-12 [Localidad tipo: Illa Plana, Islas Bledas].

Concha globosa poco calcificada, de estriación muy fina y comprimida, color castaño claro, algo traslúcida, con bandas espirales en general poco marcadas, diluidas en la pigmentación de fondo. Abertura oblicua, ovalada con el borde superior muy descendente en su extremidad, llegando generalmente hasta la quinta banda espiral. Peristoma blanco, algo reflejado. Sin ombligo.

Distribución: Illa Plana y Na Gorra (Islas Bledas).

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APÉNDICE I. MATERIAL ESTUDIADO

Listado de ejemplares estudiados, ordenados por taxones. Abreviaturas: MLL: Mallorca, ME: Menorca, IB: Ibiza. *Los ejemplares de *A. (I.) h. tanitianus* de Cala Xarraca (Ibiza) provienen de depósitos cuaternarios.

ESPECIE	LOCALIDAD	EJEMPLARES	COORDENADAS U.T.M.		
			HUSO	X	Y
A. (A.) grateloupi	Finca Mortitx (MLL)	3	31 S	493582	4413048
A. (A.) grateloupi	Sa Calobra (MLL)	3	31 S	483684	4411182
A. (A.) grateloupi	Ctra. Ma 10 pk 26 (MLL)	3	31 S	486092	4408729
A. (I.) h. hispanicus	Mirador de Ses Barques (MLL)	3	31 S	478015	4404977
A. (I.) h. hispanicus	Puigpunyent (MLL)	1	31 S	459623	4387551
A. (I.) h. hispanicus	Puig de la Verge (MLL)	3	31 S	499946	4412992
A. (I.) h. hispanicus	Escorça (MLL)	10	31 S	490373	4407310
A. (I.) h. hispanicus	Santuari de Lluc (MLL)	10	31 S	490701	4408136
A. (I.) h. hispanicus	Font des Padro, Biniamar (MLL)	1	31 S	510895	4410466
A. (I.) h. hispanicus	Calviá (MLL)	1	31 S	457202	4376647
A. (I.) h. hispanicus	Finca Mortitx (MLL)	4	31 S	493588	4413288
A. (I.) h. hispanicus	Ctra. Ma 10 pk 106 (MLL)	3	31 S	449046	4384111
A. (I.) h. hispanicus	Ctra. Ma 10 pk 98 (MLL)	1	31 S	452971	4388564
A. (I.) h. hispanicus	Ctra. Ma 10 pk 80 (MLL)	3	31 S	461454	4392524
A. (I.) h. hispanicus	Ctra. Ma 1110 pk 14 (MLL)	2	31 S	468636	4393742
A. (I.) h. hispanicus	Golf "Camp de Mar" (MLL)	1	31 S	449980	4377903
A. (I.) h. hispanicus	La Granja (Esporles) (MLL)	6	31 S	462198	4391224
A. (I.) h. hispanicus	Ctra. Ma 10 pk 45 (MLL)	3	31 S	476556	4404068
A. (I.) h. hispanicus	Ctra. Ma 10 pk 26 (MLL)	4	31 S	486092	4408729
A. (I.) h. hispanicus	Sa Dragonera (MLL)	1	31 S	442261	4382366
A. (I.) h. hispanicus	Ctra. Ma 10 pk 12 (MLL)	1	31 S	493068	4412721
A. (I.) h. hispanicus	Castillo de Alaró (MLL)	1	31 S	482167	4398217
A. (I.) h. hispanicus	Cala Figuera (Paguera) (MLL)	1	31 S	451073	4375703
A. (I.) h. campanyonii	Cala Blava – Cala Pi (MLL)	1	31 S	478300	4367768
A. (I.) h. campanyonii	Palma de Mallorca (MLL)	2	31 S	468760	4380346
A. (I.) h. campanyonii	Ctra. Ma 10 pk 80 (MLL)	3	31 S	461454	4392524
A. (I.) h. campanyonii	Puig Na Morisca (MLL)	2	31 S	455350	4373179
A. (I.) h. campanyonii	Font de Sa Cala (MLL)	7	31 S	538823	4390660
A. (I.) h. campanyonii	Isla de Cabrera	8	31 S	494500	4333434
A. (I.) h. campanyonii	Isla de Cabrera. Punta de N'Ansiola	3	31 S	493459	4331247
A. (I.) h. campanyonii	Illa dels Conils (Cabrera)	10	31 S	496618	4337582
A. (I.) h. campanyonii	Tarragona murallas	11	31T	353953	4553570
A. (I.) h. horadadae	Na Foradada (Cabrera)	30	31 S	498173	4339780
A. (I.) h. palumbariae	Illa d'en Colom (ME)	4	31 S	609075	4423829
A. (I.) h. minoricensis	Ciutadella de Menorca (ME)	16	31 T	571248	4428299
A. (I.) h. minoricensis	Es Tancants (Algairens) (ME)	8	31 T	578247	4433364
A. (I.) h. minoricensis	Ses Mongetes (ME)	5	31 S	572244	4421521
A. (I.) h. minoricensis	Ses Olles (ME)	9	31 T	599695	4432000
A. (I.) h. minoricensis	Algendar (ME)	7	31 S	583499	4425806
A. (I.) h. minoricensis	Son Febrer (ME)	10	31 S	579926	4426000
A. (I.) h. minoricensis	Canteras Bona Nova (ME)	5	31 T	574426	4428678
A. (I.) h. minoricensis	Son Saura – Es Talaier (ME)	3	31 S	576396	4420157
A. (I.) h. minoricensis	Cala Es Pous (ME)	4	31 T	570505	4433511
A. (I.) h. minoricensis	Cala En Bastó (ME)	4	31 S	570908	4423146
A. (I.) h. minoricensis	Cap de Cavalleria (ME)	2	31 T	593166	4438153

A. (I.) h. minoricensis	Cala de S'Enclusa (ME)	3	31 T	597376	4433575
A. (I.) h. minoricensis	Maó (ME)	3	31 S	602652	4414086
A. (I.) h. minoricensis	Ibiza (IB)	4	31 S	363780	4307778
A. (I.) h. minoricensis	Ses Balandres (IB)	4	31 S	353999	4322934
A. (I.) h. tanitianus	Cala Salada (IB)	8	31 S	352715	4319319
A. (I.) h. tanitianus	Col de Sa Creu (IB)	16	31 S	349341	4309041
A. (I.) h. tanitianus	Cala Sant Vicenç (IB)	11	31 S	378097	4325938
A. (I.) h. tanitianus	Cala Xarraca (IB)*	5	31 S	370759	4329052
A. (I.) h. pythiusensis	Na Plana (Islas Bledas) (IB)	11	31 S	340605	4316155
A. (I.) h. pythiusensis	Na Gorra (Islas Bledas) (IB)	3	31 S	341061	4314868

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Heterobranch Gastropods from Cuba: the family Cornirostridae (Heterobranchia, Valvatoidea)

Gasterópodos Heterobranquios de Cuba: la familia Cornirostridae (Heterobranchia, Valvatoidea)

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RESUMEN

Se estudian 4 especies de gasterópodos Heterobranquios de la familia Cornirostridae, pertenecientes a los géneros *Cornirostra* Ponder, 1990 y *Tomura* Pilsbry & McGinty, 1946, encontradas en la Isla de Cuba. Dos de ellas, *Cornirostra floridana* Bieler & Mikkelsen, 1998 y *Tomura bicaudata* (Pilsbry & McGinty, 1946) son especies previamente conocidas y otras dos, se describen como nuevas para la ciencia. Se ilustran mediante fotografias al MEB y se aportan datos de batimetría, hábitat y distribución.

ABSTRACT

Four species of Heterobranch gastropods of the family Cornirostridae, belonging to the genera *Cornirostra* Ponder, 1990 and *Tomura* Pilsbry & McGinty, 1946, were found in the island of Cuba and are now studied. Two of them, *Cornirostra floridana* Bieler & Mikkelsen, 1998 and *Tomura bicaudata* (Pilsbry & McGinty, 1946), were previously known and the other two are described as new species. They are illustrated by SEM photographs and data on their bathymetry, habitat and distribution is provided.

INTRODUCTION

The Lower Heterobranchia gastropods, also known as the Allogastropoda, are an informal group of rather specialized and highly-evolved marine gastropod molluscs which include among others the superfamily Valvatoidea Gray, 1840. This superfamily comprises three families of Recent molluscs (Valvatidae Gray, 1840; Cornirostridae Ponder, 1990 and Hyalogyrinidae Warén & Bouchet, 1992) and a family of fossil molluscs (Provalvatidae Bandel, 1991).

PONDER (1990) introduced the family Cornirostridae to include two monotypic genera: *Cornirostra* (based on *C. pellucida*) and *Tomura* (based on *T. bicaudata*). WARÉN, GOFAS & SCHANDER (1993) described a new genus, *Noerrevangia* Warén & Schander, 1993, which is included in Cornirostridae and designated *Noerrevangia fragilis* as the type species of this new genus.

BIELER, BALL & MIKKELSEN (1998) provided a redescription of the family Cornirostridae after a detailed anatomi-

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Tabla I. Comparación de los caracteres morfológicos en las especies estudiadas con otras congenéricas.

	Cornirostra pellucida	*Cornirostra floridana*	*Comirostra lenticulata*	*Tomura bicaudata*
Shell spire	115-140°	105-110°		130-140°
Umbilicus	Open, unkeeled	Open, unkeeled	Open, unkeeled	Open, keeled
Maximun size	2.3 mm	2.1 mm	1.35 mm	1.25 mm
PC size	217 µm	108-185 µm	180 µm	165-195 µm
PC coiling	Initial hyperstrophy	Initial hyperstrophy	Initial hyperstrophy	Initial hyperstrophy
PC whorls	1.25	1.20	1.20	1.25
TC whorls	2.75	2.05-2.95	2.5	2.0-2.25
PC II sculpture	Smoth	Smooth	Smooth	Smooth, initial part with 0-2 spiral ridges
TC sculpture	Smooth	Smooth	Fine growth lines	Smooth

cal and morphological study of specimens collected alive of *Cornirostra floridana*, and its comparison with *Tomura bicaudata* and other known species of the family.

Currently the family Cornirostridae comprises 12 species, placed one in *Noerrevangia*, 2 in *Cornirostra* and 9 in *Tomura*. Among them, *Tomura bicaudata*, *Tomura xenoskeneoides* and *Cornirostra floridana* were described from the Central West Atlantic. In the present work four species of heterobranch molluscs are studied from Cuba, two of them being previously known (*C. floridana* and T. *bicaudata*) and two new for science.

The comparison of the morphological characters can be seen in Table I.

MATERIAL AND METHODS

The material has been collected either by SCUBA diving or dredgings, mostly by the third author (RFG). No live specimens were observed.

The shells were photographed with an XL-30 Electronic microscope of the University of Vigo.

Abbreviations used:

ANSP, Academy of Natural Sciences, Philadelphia
MNCN, Museo Nacional de Ciencias Naturales, Madrid, Spain
FLMNH, Florida Museum of Natural History, Gainesville, Florida, USA
MHNS, Museo de Historia Natural, Santiago de Compostela, Spain
MNHN, Museum national d'Histoire naturelle, Paris, France
IES, Instituto de Ecología y Sistemática, Havana, Cuba
CFG, collection of Raúl Fernandez-Garcés
j, juvenile
s, shell (adult)
SEM, Scanning electron micrograph

SYSTEMATIC PART

Subclass Heterobranchia J.E. Gray, 1840
Superfamily Valvatoidea J.E. Gray, 1840
Family Cornirostridae Ponder, 1990

Table I. Comparison of morphological characters of the studied species with other congeneric.

Tomura yashima	*Tomura himeshima*	*Tomura depressa*	*Tomura apextruncatus*	*Tomura xenoskenoides*
>140°	>140°	130°		
Open, unkeeled	Open, unkeeled	Callus-filled	Callus-filled	Open, unkeeled
1.5 mm	1.9 mm	1.6 mm	1.8 mm	1.86
180-200 µm	200 µm	150-175 µm	150-180 µm	160 µm
Initial hyperstrophy	Initial hyperstrophy	hyperstrophy	hyperstrophy	Initial hyperstrophy
1.50	1.50	1.7	1.25	0.75
2.0-2.25	2.25	2.0	2.75	3.0
Unknown	Smooth	Smooth	Incremental lines	Smooth
Fine growth lines, very weak spiral threads; with thin transparent periostracum	Rough growth lines, very weak spiral threads; with thick, yellowish periostracum	Occasionally initially with spiral ridges	Fine spiral cordlets more evident on the dorsum and on the base	Fine growth lines

The redescription of the Cornirostridae family in BIELER, BALL & MIKKELSEN (1998) is as follows: "Small (<2.3 mm) valvatoideans with (almost) smooth skeneiform teleoconchs of 2-3 more-or-less convex whorls and simple peristome, and (weakly) sinistral protoconchs coiling around the same axis (this hyperstrophic larval might not be expressed if only protoconch I [embryonic shell] is present, e.g., *Noerrevangia*); snout long, with two tentacle-like oral lobes; radula with 7-9 teeth per row including 2-3 partly overlapping lateral teeth, and rachidian with highly developed lateral support; foot with propodial and metapodial extensions, appearing left anteriorly and posteriorly; single right pallial tentacle; bipectinate, basally attached gill; hermaphroditic reproductive system with cephalic penis".

BIELER *ET AL.* (1998) wrote: "Extant cornirostrids with their non-descript, skeneiform/valvatiform/vitrinelliform shells can only be confirmed as members of this family through knowledge of their anatomical features. [...] Attempts to establish a deep fossil record for the family (SCHRÖDER, 1995; BANDEL, 1996) by "connecting-the-dots" between Recent, Cretaceous, Jurassic, and Triassic taxa with similarly non-descript shells should thus be viewed with caution".

One of the main morphological characters which differentiate and characterize the species included in Cornirostridae (except *Noerrevangia fragilis*) is to have a slightly hyperstrophically coiled larval shell. Similarly weakly expressed larval hyperstrophy also occurs in other lower heterobranchs, such as *Xenoskenea* Warén & Gofas, 1993, Hyalogyrinidae, and Omalogyridae (BIELER *ET AL.*, 1998).

The species of Cornirostridae are astonishingly similar in shell characters to species of Vitrinellidae of the genera *Teinostoma* and *Vitrinella*, but shells can still be distinguished by the hyperstrophy of the larval shell.

Genus *Cornirostra* Ponder, 1990

Cornirostra Ponder, 1990. *Journal of Molluscan Studies*, 56 (4): 533-555. [Type species by original designation: *Microdiscula pellucida* Laseron, 1954].

Remarks: Only two species have so far been described in this genus: *Cornirostra pellucida* (Laseron, 1954) from the Indo-West Pacific, and *Cornirostra floridana* Bieler & Mikkelsen, 1998 from the West Atlantic.

Cornirostra floridana Bieler & Mikkelsen, 1998 (Fig. 1)

Cornirostra floridana Bieler & Mikkelsen, 1998. *Malacologia*, 40: 307-313, figs. 1-13. [Type locality: Indian Key Fill, mile marker 79, Middle Florida Keys, bay side (Gulf of Mexico), Monroe County, Florida].

Type material: Holotype in FLMNH (278401) and seven paratypes in FLMNH, ANSP and USNM, not examined.
Other material examined: 6 s, Calicito, Cienfuegos Bay, Cuba, 12 m (CFG); 10 s, Cienfuegos Bay, 12-16 m (MHNS).

Description: Shell small (up to 2.1 mm), transparent, with relatively high spire and rounded periphery, smooth with fine growth lines. Protoconch initially hyperstrophic, later nearly planispiral, with a little more than one spiral whorl, measuring about 180 µm in maximum diameter and having two well differentiated parts: Protoconch I (embryonic shell) with a reticulated sculptural pattern; Protoconch II (larval shell) smooth, finishing in a labial thickening. Teleoconch with nearly 2 ½ whorls; transparent, smooth with fine growth lines. Base smooth, umbilicate, without umbilical keel or cord; the growth lines penetrate into the inner part of the umbilicus. Aperture oval, external lip and columella sharp, not thickened.

Maximum reported size: 2.1 mm. The largest specimen in the examined material measures 1.96 mm in diameter and 1.52 mm in height.

Habitat: Live–observed specimen among turtle grass (*Thalassia testudinum*) and green algae (*Penicillus cf. dumetosus* and *Halimeda spp.*), in shallow water (0-1 m) at low tide (Bieler *et al.*, 1998).

Distribution: USA: Florida Keys (Bieler *et al.*, 1998). The known geographic range is extended to Cienfuegos Bay, Cuba.

Remarks: The description follows essentially Bieler *et al.* (1998). *Cornirostra floridana* differs from *Tomura bicaudata* by its smaller spire angle (105°-110° vs 130-140°) and by the absence of the umbilical keel.

Cornirostra lenticulata spec. nov. (Fig. 2)

Type material: Holotype (s) deposited in MNCN (15.05/60047). One paratype (s) in MNHN (25141), one more (j) in IES and two (s and j) in MHNS (100572).
Type locality: Calicito, 22° 07.970′ N, 80° 29.824′ W, Cienfuegos Bay, Cuba, 8 m, Cuba.
Etymology: The species name refers to the shape of the shell, which resembles a lentil in shape. From the Latin word *lenticulatus*.

Description: Shell of very small size (scarcely 1.4 mm), lenticular, more or less depressed, transparent and almost smooth. Protoconch hyperstrophic, with a little more than one spiral whorl, measuring about 180 µm in maximum diameter and having two well differentiated parts: Protoconch I (embryonic shell) with a reticulated sculptural pattern; Protoconch II (larval shell) smooth, finishing in a labial thickening. Teleoconch with nearly 2 ½ whorls; transparent, smooth with fine growth lines. Base smooth, umbilicate, without umbilical keel or cord; the growth lines penetrate the inner part of the umbilicus. Aperture oval, external lip and columella sharp, not thickened.

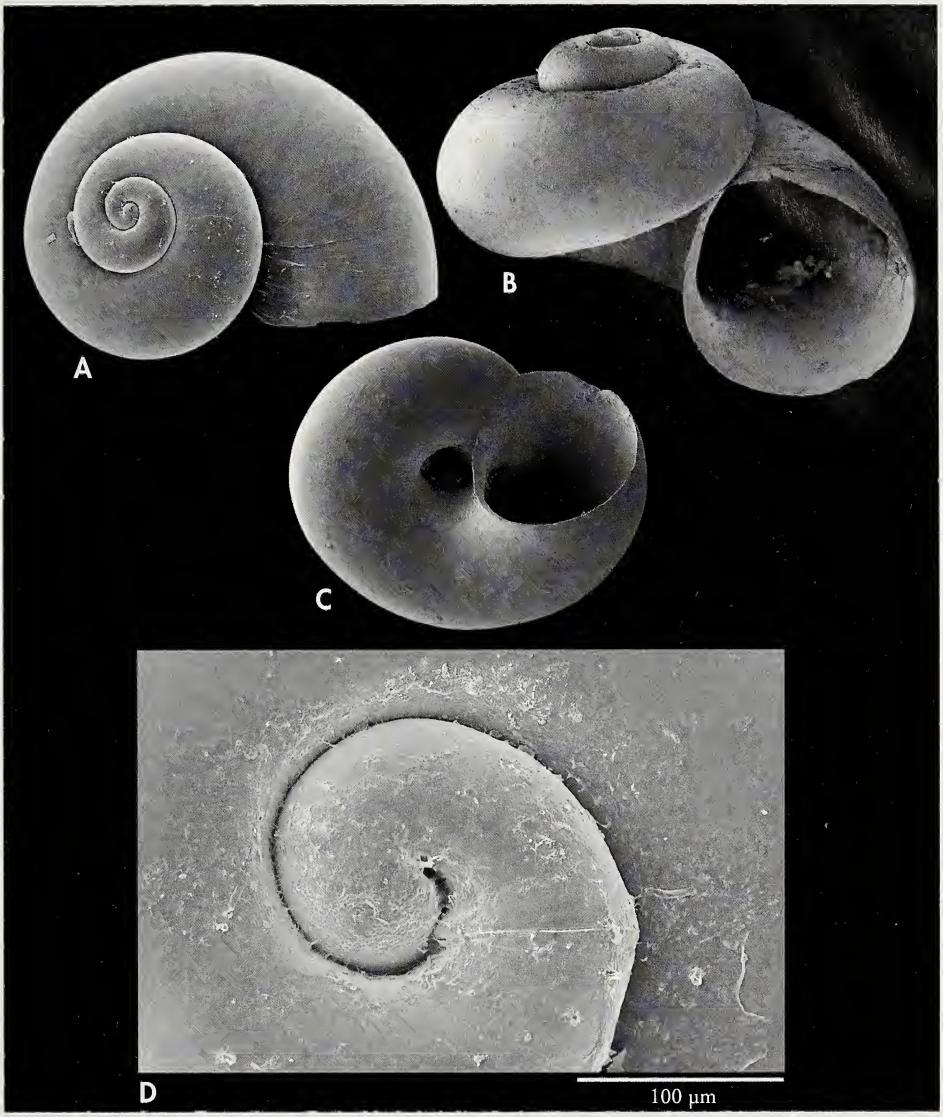

Figure 1. *Cornirostra floridana* Bieler & Mikkelsen, 1998. A-C: shells, 1.7, 1.9, 1.4 mm in diameter, Calicito, Cienfuegos Bay; D: protoconch of another specimen, same locality.
Figura 1. Cornirostra floridana *Bieler & Mikkelsen, 1998. A-C: conchas, diámetro 1,7; 1,9; 1,4 mm, Calicito, bahía de Cienfuegos; D: protoconcha de otro ejemplar, misma localidad.*

Maximum reported size: holotype is 1.35 mm in maximum diameter.

Habitat: The material studied was found in sediments in a coralline bottom at 30 m depth.

Distribution: Only known from Calicito, Cienfuegos Bay, Cuba, its type locality.

Remarks: Like the holotype (Fig. 2A), some shells have a separation between the end of the teleoconch spire and the previous whorl; probably this may be an occasional character or perhaps present only in very mature shells.

Cornirostra lenticulata spec. nov. has some characters which indicate a rela-

tionship with *C. floridana*, such as: the reticulated sculptural pattern of the larval shell; the diameter of the protoconch; the smooth and transparent teleoconch shell; and the umbilicus without any keel. However, it may be distinguished from its congeneric species by its lenticular form, more depressed than in *C. floridana*.

Genus *Tomura* Pilsbry & McGinty, 1946

Tomura Pilsbry & McGinty, 1946. *Nautilus*, 60: 15. Type species by monotypy *Vitrinella (Tomura) bicaudata* Pilsbry & McGinty, 1946. Florida.

Remarks: Pilsbry & McGinty (1945) figured the crawling animal and shell of the type species. Ponder (1990) described it in some detail after topotypic material. Bieler *et al.* (1998) compared *T. bicaudata* with the new species described, *Cornirostra floridana* and gave some information on its localization.

Nine species are presently known in the genus *Tomura*: *T. yashima* Fukuda & Yamashita, 1997 and *T. himeshima* Fukuda & Yamashita, 1997 from Japan; *T. depressa* (Granata-Grillo, 1877) from the Mediterranean Sea and the Atlantic coast of Morocco; *T. abscondita* Rolán & Rubio, 1999, *T. sphaerica* Rolán & Rubio, 2008, and *T. umbiliobsessa* Rolán & Rubio, 2008, all from West African coasts; *T. bicaudata* (Pilsbry & McGinty, 1946) and *Tomura xenoskenoides* Rubio & Rolán, 1998, from the West Atlantic Ocean and *T. aqabaensis* Bandel, 2010, from the Red Sea.

Among the nine known species placed in the genus *Tomura*, five, after examination of their anatomy and radula, were placed in four morphotypes: 1) *T. bicaudata*; 2) *T. depressa* (Granata-Grillo 1877); 3) *T. yashima* Fukuda & Yamashita, 1997 and *T. himeshima* Fukuda & Yamashita, 1997; 4) *T. xenoskeneoides*.

The new species of *Tomura* here described belongs to the morphotype of *T. depressa*, characterized by having "the appearance of a miniaturized *Natica* and the umbilicus filled out by a callus".

Tomura bicaudata (Pilsbry & McGinty, 1946) (Fig. 3)

Vitrinella (Tomura) bicaudata Pilsbry & McGinty, 1946. *Nautilus*, 60: 15-16. [Type Locality: Missouri Key, Florida (26.8° N to 12° N; 81.2° W to 74° W)].

Type material: In ANSP. Not examined.
Other material examined: 4 s, Cienfuegos Bay, coralline sand, 12 m; 3 sp, Rancho Luna Beach, 40 m (MHNS).

Description: Shell very small, rather thin, wider than high (H/D: 0.63), globosely depressed, umbilicate, the width of umbilicus contained nearly 5 times in the diameter. The protoconch size is between 150 and 160 µm and it presents 2 well differentiated parts. Protoconch I (embryonic shell), with about ½ whorl and with a granulose pattern, clearly hyperstrophic, partially visible. Protoconch II (larval shell) is hyperstrophic, almost smooth with incremental lines, with ¾ whorl, and thickened a short distance from its termination. As a result of the slightly hyperstrophic coiling of the protoconch, the apex forms a minute depression. Teleoconch with 2 ¼ whorls, separated by an indistinct and shallow suture. Upper surface of whorls smooth, evenly convex. Base convex, becoming a little concave near the strong angle or cord which overhangs the umbilicus. Aperture rounded, only slightly prosocline; outer lip thin; columellar margin very slightly thickened, arcuate. Parietal callus thin.

Maximum reported size: the holotype measures 1.2 mm in diameter and

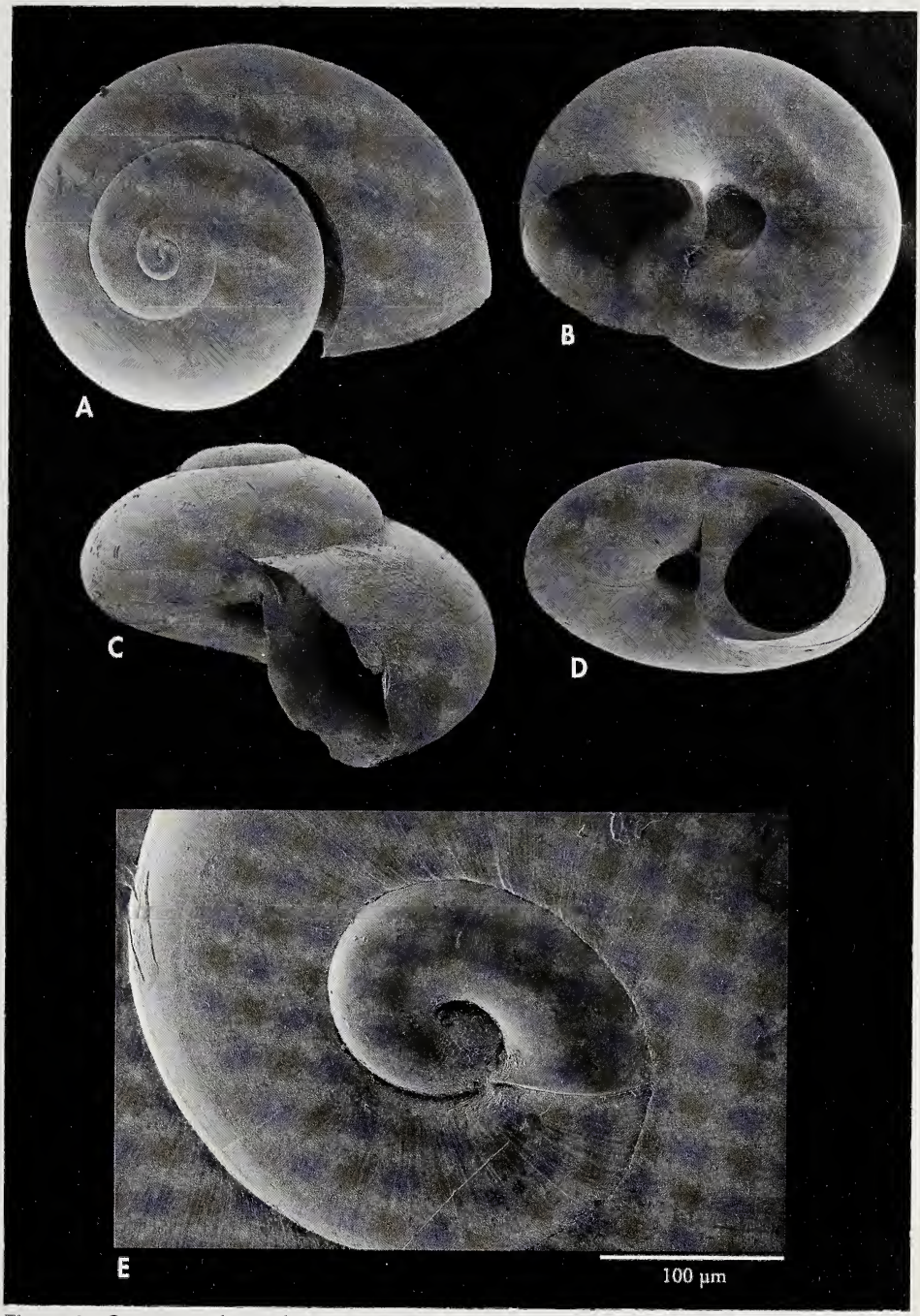

Figure 2. *Cornirostra lenticulata* spec. nov. A: holotype, 1.35 mm in diameter (MNCN); B: paratype, 1.1 mm (MNHN); C, D: paratypes, 1.2 and 1.05 mm (MHNS), all from Calicito, Cienfuegos Bay, Cuba; E: protoconch of a juvenile paratype, same locality.

Figura 2. Cornirostra lenticulata *spec. nov. A: holotipo, diámetro 1,35 mm (MNCN); B: paratipo, 1,1 mm (MNHN); C, D: paratipos, 1,2 y 1,05 mm (MHNS), todos de Calicito, Bahía de Cienfuegos; E: protoconcha de un paratipo juvenil, misma localidad.*

0.75 mm in height (H/D: 0.63). Maximum reported size: 1.5 mm.

The extremely thin operculum is slightly concave externally, of the multispiral type with subcentral nucleus; the spiral figure is indistinct, but somewhat over one whorl is visible.

Habitat: Living under rocks (PILSBRY & MCGINTY, 1946). Depth: 0 m

Distribution: USA: Florida Keys: Lake Surprise and Missouri Key, Monroe County, Florida (BIELER *ET AL.*, 1998; PILSBRY & MCGINTY, 1946)). Colombia (DÍAZ MERLANO & PUYANA HEGEDUS, 1994) and Cienfuegos Bay, Cuba (in the present work).

Remarks: The above description is essentially taken from PILSBRY & MCGINTY (1946: 15-16) except for the details of protoconch added from the material examined herein. After the original description, PILSBRY & MCGINTY (1946) comment: "This is a more elevated shell than *Vitrinella helicoidea* C. B. Adams, with relatively larger aperture and smaller umbilicus. One of us (T.L.M.) took three of these, all with the same cleft tail, and kept them living together. They may be cannibalistic, for on the third day the animal of one was gone and on the fourth day only a single specimen remained alive. When the living animal was found last year we thought that it represented a new genus which we called *Tomura* (*Nautilus*, vol. 59, pi. 2, fig. 9). The animal is formed as in *Vitrinella* except that the foot is bifid posteriorly, and the tentacles do not appear to bear any cilia; but the shell has all the characters of the typical section of *Vitrinella*. Pending further studies of many micromolluscs groups we are holding the status of *Tomura* in suspense, as it could not be recognized by the shell alone".

Tomura bicaudata may be distinguished from the other species of *Tomura* except *T. umbiliobsessa* Rolán & Rubio, 2008, by having an open umbilicus and an umbilical cord like a keel bordering it.

The most similar species is *T. umbiliobsessa*, because both have a similar shape of the aperture and periumbilical keel, but they may be separated because *T. bicaudata* has a smooth shell surface and that of *T. umbiliobsessa* is covered with pits.

Tomura apextruncatus spec. nov. (Fig. 4)

Type material: Holotype in MNCN (15.05/60048).
Other material examined: 2 s, Maria la Gorda, Guanahacabibes, Pinar del Rio, Cuba (broken during the study).
Type locality: Calicito, 22° 07.970′ N, 80° 29.824′ W, Cienfuegos Bay, Cuba, at -8 m.
Etymology: The specific name (in apposition) alludes to the flat apex of the shell.

Description: Shell very small, a little wider than high (H/D: 0.77), globose, with a rather solid umbilical callus. The protoconch size is between 150 and 180 µm and presents 2 well differentiated parts. Protoconch I (embryonic shell), with about a half whorl and with a reticulated sculptural pattern, is partially visible. Protoconch II (larval shell) is hyperstrophic, almost smooth with incremental lines, with ¾ of whorl, ending in a thick varix. As the protoconch has a near-planispiral coiling the apical aspect of the shell is truncated. Teleoconch with 2 ¾ whorls, separated by an indistinct and shallow suture. Apparently smooth, it shows fine spiral cordlets, more evident on the dorsum and on the base of the shell than in the periphery, where they are scarcely perceptible. Aperture rounded, prosocline; outer lip thin; parietal area almost without a callous coating; arched columella, very widened and reflected, forming a strong umbilical callus.

Maximum reported size: the holotype measures 1.77 mm in diameter and 1.37 mm in height (H/D: 0.77). The material from Maria la Gorda measures

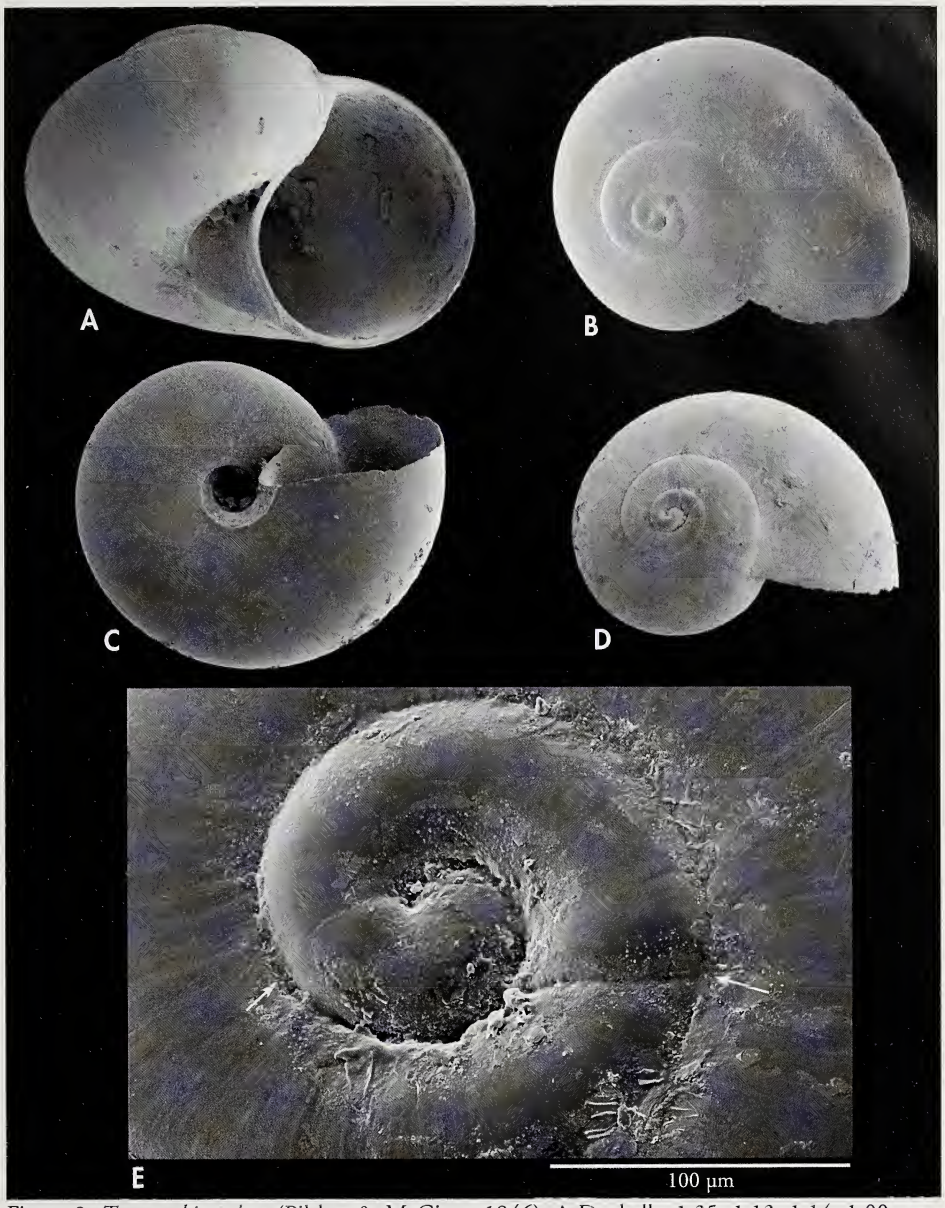

Figure 3. *Tomura bicaudata* (Pilsbry & McGinty, 1946). A-D: shells, 1.35, 1.13, 1.14, 1.00 mm, Cienfuegos Bay, Cuba; E: protoconch of a juvenile specimen, same locality.
Figura 3. Tomura bicaudata *(Pilsbry & McGinty, 1946). A-D: conchas, 1,35; 1,13; 1,14; 1,00 mm, bahía de Cienfuegos, Cuba; E: protoconcha de otro ejemplar de la misma localidad.*

less than 1.1 mm in diameter and about 0.84 mm in height (H/D: 0.77).

Habitat: The shell from Calicito, Cienfuegos Bay, was dredged in coralline sand bottom at 8 m. Those from Maria la Gorda were collected in coralline sediments at 30 m in depth.

Distribution: Only known from Calicito, Cienfuegos and Maria la Gorda, Cuba Island.

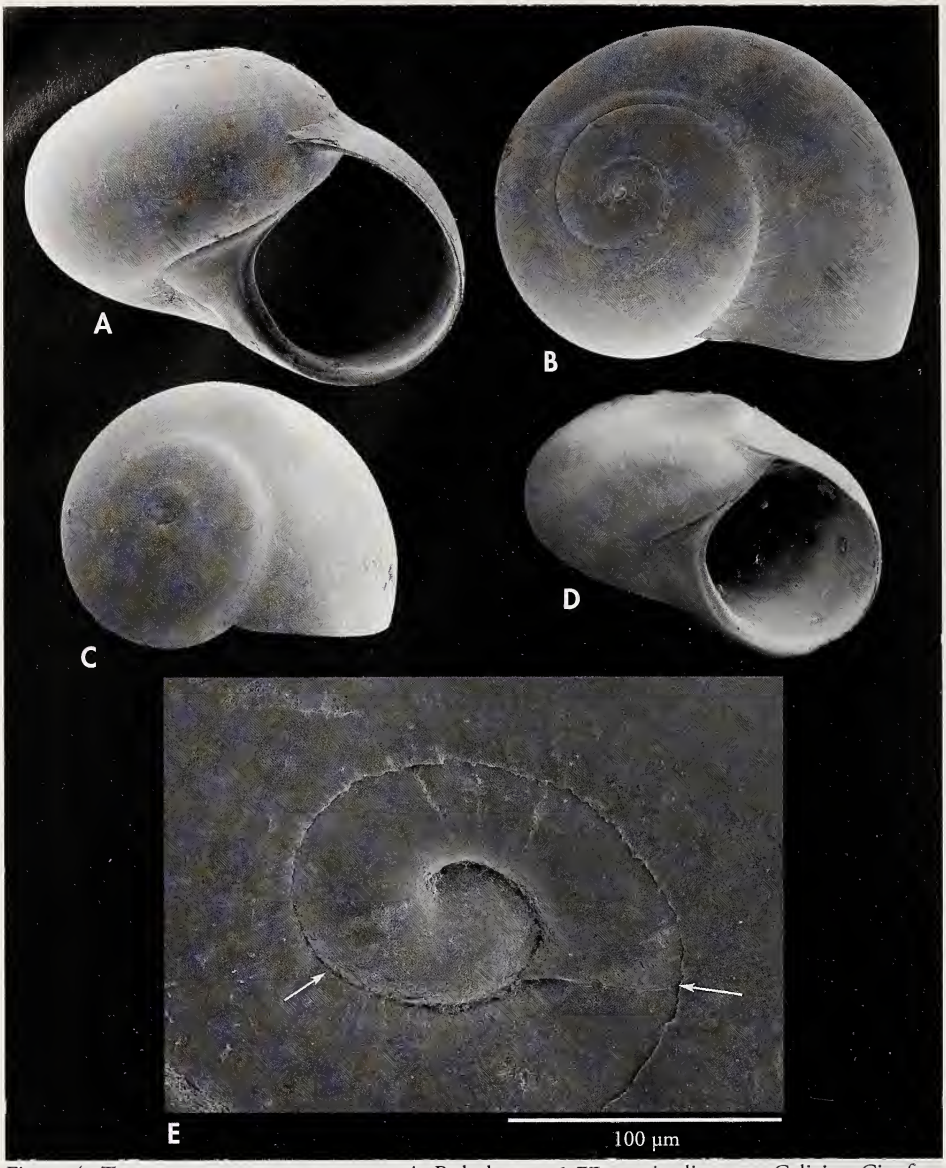

Figure 4. *Tomura apextruncatus* spec. nov. A, B: holotype, 1.77 mm in diameter, Calicito, Cienfuegos Bay, Cuba (MNCN); C, D: shells, 1.04, 1.05 mm in diameter, María la Gorda, Guanahacabibes, Cuba; E: protoconch of another specimen, same locality.

Figure 4. Tomura apextruncatus *spec. nov. A, B: holotipo, diámetro 1,77 mm, Calicito, bahía de Cienfuegos, Cuba (MNCN); C, D: conchas, diámetro 1,04 y 1,05 mm, María la Gorda, Guanahacabibes, Cuba; E: protoconcha de otro ejemplar de la misma localidad.*

Remarks: *Tomura apextruncatus* spec. nov. may be distinguished from *T. bicaudata* by the round aperture, the lack of periumbilical keel and the umbilicus occluded by a strong callus. It can be separated from *Tomura xenoskeneoides* by the globular form of the shell, the presence of fine spiral cordlets on the teleoconch and the strong callus which occludes the umbilicus.

ACKNOWLEDGEMENTS

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Notas breves

New images of the soft parts of *Skenea serpuloides* (Prosobranchia, Turbinidae)

Nuevas imágenes de las partes blandas de *Skenea serpuloides* (Prosobranchia, Turbinidae)

Federico RUBIO* and Emilio ROLÁN**

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INTRODUCTION

At present the subfamily Skeneinae (Prosobranchia) family Turbinidae includes 42 genera, their several species inhabiting every sea, from the lower intertidal level down to abyssal depths. It has been always considered a polyphyletic group of species, characterized by its extremely reduced size and the lack of a nacreous layer. Nevertheless, as further study has been done on the anatomy and radula of many such species, quite a few of them have been transferred to other families.

The poor knowledge of animals of Skeneinae species is the reason why we decided to show the SEM images obtained using the technique of critical-point dried specimens of *Skenea serpuloides* (Fleming, 1825), type species of the genus, from which only the brief anatomical description provided by FRETTER & GRAHAM (1977) was known.

RESULTS

Genus *Skenea* Fleming, 1825

Skenea Fleming, 1825. *Edinburgh Philosophical Journal*, 12: 246. [Type species, subsequent designation by Gray (1847): *Helix serpuloides* Montagu, 1808, Great Britain].

Delphinoidea Brown, 1827. [Type species by subsequent designation Gray (1847): *Helix serpuloides* Montagu, 1808].

Remarks: VAN AARTSEN, MENKHORST & GITTENBERGER (1984) were the first to present SEM photographs of the shell of *Skenea serpuloides* from Algeciras Bay. WARÉN (1991) also provided SEM photographs of shell, operculum and radula. RUBIO-SALAZAR (1991: 189) provided a drawing of the animal, detailing

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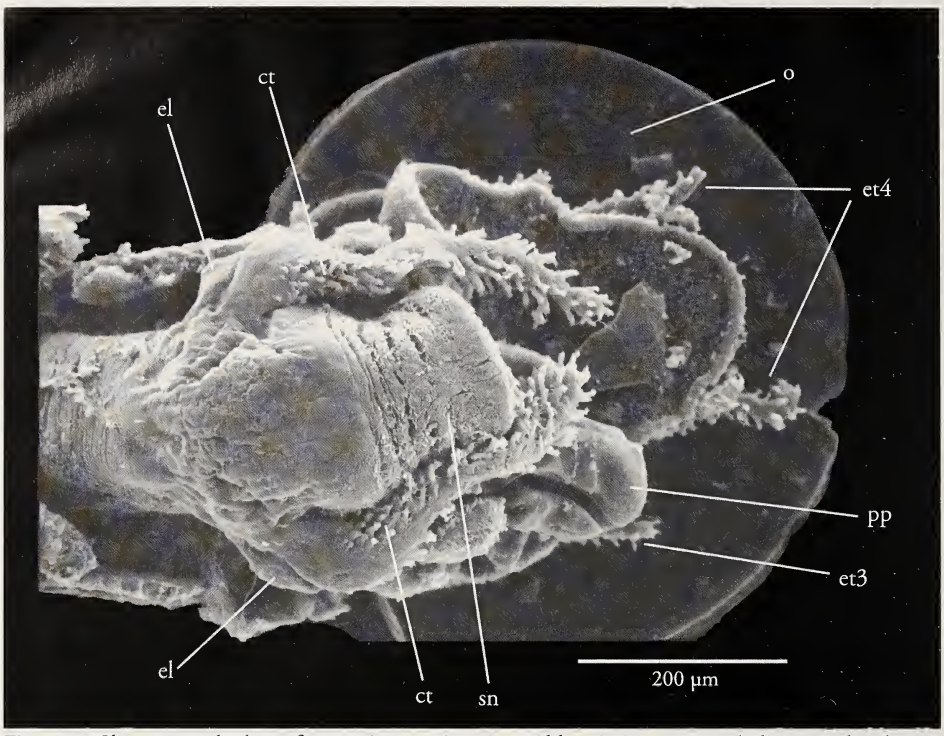

Figure 1. *Skenea serpuloides*, soft parts in anterior view. Abbreviations, ct: cephalic tentacle; el: eye-lobes; et3, et4: epipodial tentacles 3 and 4; o: operculum; pp: propodial penis; sn: snout.
Figura 1. Skenea serpuloides, *partes blandas vistas desde la parte anterior. Abreviaturas, ct: tentáculo cefálico; el: lóbulos oculares; et3, et4: tentáculos epipodiales 3 y 4; o: opérculo; pp: pene propodial; sn: hocico.*

its different organs. However, nothing has been published so far as SEM photographs of the animal of *S. serpuloides*, which we present below.

Skenea serpuloides (Montagu, 1808)

Helix serpuloides Montagu, 1808. *Testacea Britannica* – Supplement, p. 147, pl. 21 fig. 3.

Material examined: 10 sps, from Limens, Ria de Vigo, dredged at 15-20 m, in maërl bottom.

Description: *Soft parts* (Figs. 1-3). The snout (SN) is long and broad apically. There are no anterior cephalic lappets. The cephalic tentacles (CT) are long and slender and are at least twice as long as the snout in some specimens; they are covered by sensory papillae ciliated distally (Fig. 3A). The eye-lobes (EL) are reduced to an inconspicuous lateral fold at the base of the cephalic tentacles. On the right side the eye-lobe is continuous with a single tentacle of one-third of the size of the cephalic one, distally with strongly ciliated edges (PT - postocular tentacle).

Neck lobes wide, ciliated, with a smooth margin; in both neck-lobes the cilia are distributed on the outer edge; the right neck-lobe (RNL) is long and curved distally while the left neck-lobe (LNL) widens much distally becoming spatulate in shape.

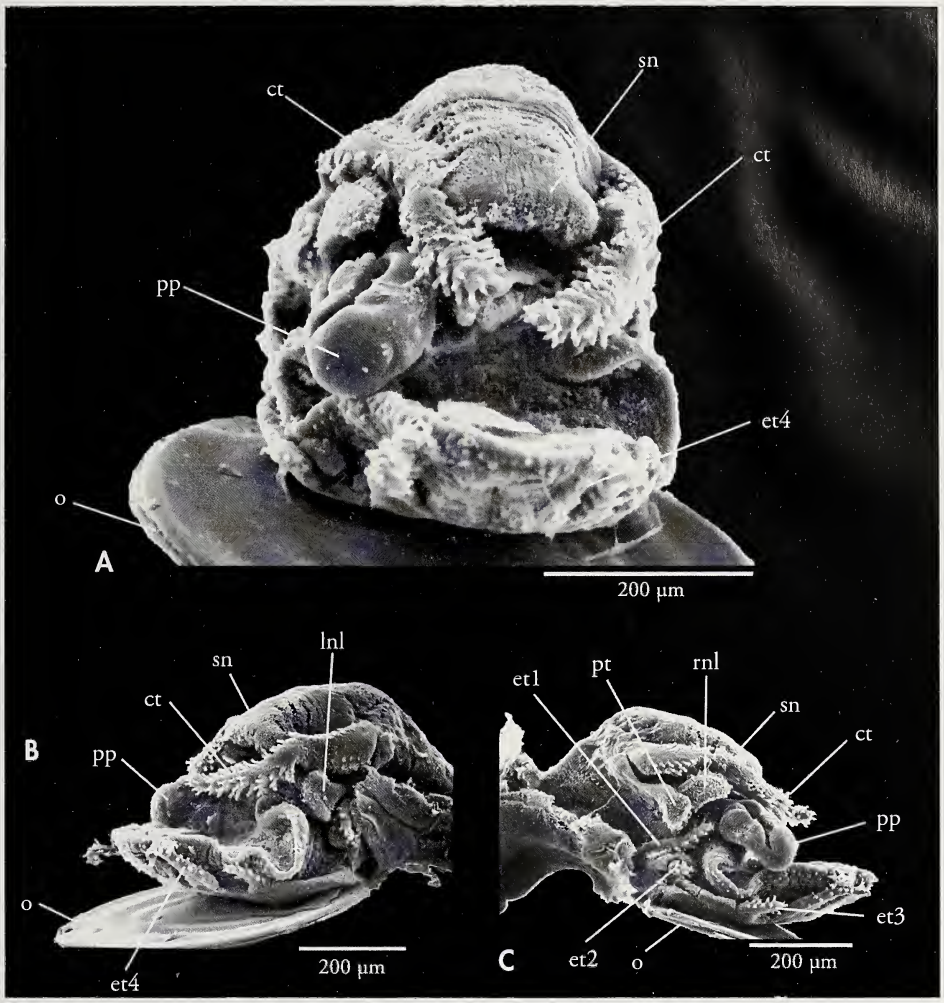

Figure 2. *Skenea serpuloides*, soft parts. A: ventral view; B: view from left side; C: view from right side. Abbreviations, ct: cephalic tentacle; el: eye-lobes; et1, et2, et3, et4: epipodial tentacles 1-4; lnl: left neck lobe; o: operculum; pp: propodial penis; pt: postocular tentacle; rnl: right neck lobe; sn: snout.
Figura 2. Skenea serpuloides, *partes blandas. A: vista ventral; B: vista desde el lado izquierdo; C: vista desde el lado derecho. Abreviaturas: ct: tentáculo cefálico; el: lóbulos oculares; et1, et2, et3, et4: tentáculos epipodiales 1-4; lnl: lóbulo cervical izquierdo; o: opérculo; pp: pene propodial; pt: tentáculo postocular; rnl: lóbulo cervical derecho; sn: hocico.*

Four epipodial tentacles (ET) on each side of the foot can be seen behind the neck-lobes. The epipodial tentacles are shorter and narrower than the cephalic ones and are distally covered by sensory papillae, although in lesser numbers. The second epipodial tentacles, located at their base and more evident on the right side of the foot, are much shorter than the first ones; the tentacle on the left side passes almost unnoticed. The third and fourth tentacles are placed on each side under the operculum.

The foot is large, flat, truncated anteriorly, rounded posteriorly, with a large propodium, which has a large penis (PP), very thick, cylindrical-shaped, which shows a deep channel that runs

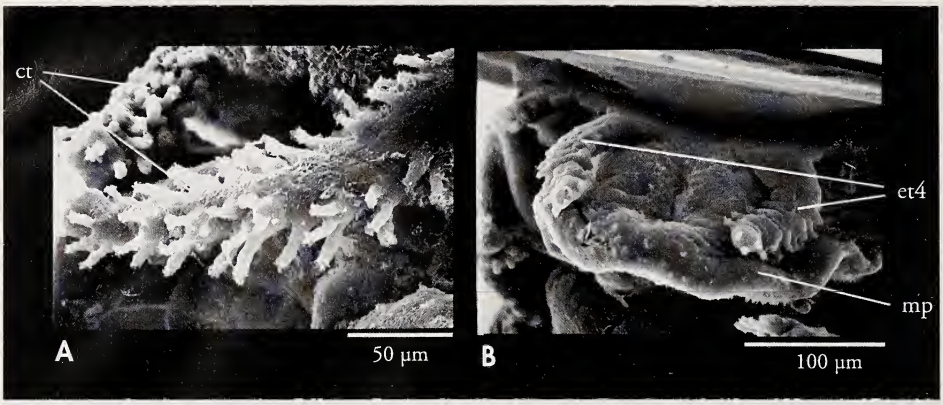

Figure 3. *Skenea serpuloides*, partial views of soft parts. A: detail of cephalic tentacle showing the distally ciliated sensory papillae; B: caudal view. Abbreviations, ct: cephalic tentacle; et4: fourth epipodial tentacles; o: operculum; mp: metapodium.

Figura 3. Skenea serpuloides, *vistas parciales de las partes blandas. A: detalle del tentáculo cefálico mostrando las papilas sensoriales ciliadas en su parte distal; B: vista posterior. Abreviaturas: ct: tentáculo cefálico; et4: cuartos tentáculos epipodiales; o: opérculo; mp: metapodio.*

completely along its length and has thick bumps on each side; the channel ends on the right side of the penis near the outer end.

The mesopodium and metapodium show randomly distributed groups of cilia. The metapodium (MP) has a deep groove that divides it in two; both sides come together at the more distal end, next to the sole. This character has not been observed in any other known species of Skeneinae.

Remarks: In relation to *Skenea serpuloides*, Fretter & Graham (1977) indicate the presence of a penis behind the right eye-lobe, but this appendage is a postocular tentacle, which lies between the right eye-lobe and neck-lobe. Although Warén & Bouchet (1993: 22) indicate that this postocular tentacle is absent in *Dikoleps nitens*, Rubio, Dantart & Luque (1998, 2004) demonstrated its existence.

An important synapomorphy of at least a part of the family is the large and, in this species, cylindrical and grooved propodial penis. Its size and shape varies from one species to another but it is present in all species of the genus *Dikoleps* (Rubio, Dantart & Luque, 1998, 2004); we have also verified its presence in the type species of the genera *Skeneoides* (*Skeneoides exilissima* (Philippi, 1844)) and *Pseudorbis* (*Pseudorbis granulum* (Brugnone, 1873)). This propodial penis has been observed in others genera such as: *Protolira* Warén & Bouchet, 1993 and *Bruceiella* Warén & Bouchet, 1993.

According to Warén & Bouchet (1993: 22), in this species there were individuals found to be simultaneous hermaphrodites, which is in agreement with the interpretation of this propodial structure as a penis.

Another differential character is the deep furrow that divides the metapodium in two parts, which only come together at the outer edge of the foot, next to the sole.

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The late Lluis Dantart made the critical-point photographs some years ago. António A. Monteiro revised the manuscript.

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Dendrodoris limbata (Cuvier, 1804)

Sinonimias

Doris limbata Cuvier, 1804, *Ann. Mus. Hist. Nat. Paris*, 4 (24): 468-469 [Localidad tipo: Marsella].

Doris nigricans Otto, 1823, *Nov. Act. Ac. Caes. Leop.-Car.*, 10: 275.

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Fretter V. y Graham A. 1962. *British Prosobranch Molluscs*. Ray Society, London, 765 pp.

Ponder W.F. 1988. The Truncatelloidean (= Rissoacean) radiation - a preliminary phylogeny. En Ponder, W.F. (Ed.): Prosobranch Phylogeny. *Malacological Review*, suppl. 4: 129-166.

Ros J. 1976. Catálogo provisional de los Opistobranquios (Gastropoda: Euthyneura) de las costas ibéricas. *Miscelánea Zoológica*, 3 (5): 21-51.

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Synonyms

Doris limbata Cuvier, 1804, *Ann. Mus. Hist. Nat. Paris*, 4 (24): 468-469 [Type locality: Marseille].

Doris nigricans Otto, 1823, *Nov. Act. Ac. Caes. Leop.-Car.*, 10: 275.

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ÍNDICE

Iberus 31 (1) 2013

RUBIO F. AND ROLÁN E. Some new species of Skeneinae (Prosobranchia, Turbinidae)
Algunas nuevas especies de Skeneinae (Prosobranchia, Turbinidae) 1-9

PUSATERI F., GIANNUZZI-SAVELLI R. & OLIVERIO M. A revision of the Mediterranean Raphitomidae 2: On the sibling species *Raphitoma lineolata* (BDD, 1883) and *Raphitoma smriglioi* n. sp.
Revisión de los Raphitomidae del Mediterráneo (Conoidea) 2: las especies hermanas Raphitoma lineolata *(BDD, 1883) y* Raphitoma smriglioi *n. sp. (Gastropoda, Conoidea)* 11-20

GUALLART J., LUQUE A.A., ACEVEDO I. Y CALVO M. Distribución y censo actualizado de la lapa ferrugínea (*Patella ferruginea* Gmelin, 1791) en el litoral de Melilla (Mediterráneo suroccidental)
*Distribution and updated census of the ferrugineous limpet (*Patella ferruginea *Gmelin, 1791) in the littoral of Melilla (SW Mediterranean)* 21-51

RODRIGUES M., TRONCOSO J.S. AND GUERRA A. Beak measurements of the Atlantic bobtail squid *Sepiola atlantica* (Cephalopoda: Sepiolidae): appropriate predictors of its body size and weight
Dimensiones de las mandíbulas de la sepiola del Atlántico Sepiola atlantica *(Cephalopoda: Sepiolidae): indicadores apropiados de su tamaño y peso* 53-61

CHUECA L.J., FORÉS M. Y GÓMEZ-MOLINER B.J. Consideraciones nomenclaturales sobre las especies del género *Allognathus* (Gastropoda: Pulmonata: Helicidae) y estudio anatómico de *Allognathus hispanicus tanitianus*
Nomenclatural considerations about Allognathus *species (Gastropoda: Pulmonata: Helicidae) and anatomical study of* Allognathus hispanicus tanitianus 63-74

RUBIO F., ROLÁN E. & FERNÁNDEZ-GARCÉS R. Heterobranch Gastropods from Cuba: the family Cornirostridae (Heterobranchia, Valvatoidea)
Gasterópodos Heterobranquios de Cuba: la familia Cornirostridae (Heterobranchia, Valvatoidea) 75-85

Notas breves

RUBIO F. AND ROLÁN E. New images of the soft parts of *Skenea serpuloides* (Prosobranchia, Turbinidae)
Nuevas imágenes de las partes blandas de Skenea serpuloides *(Prosobranchia, Turbinidae)* 87-91

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Iberus

Vol. 31 (2)

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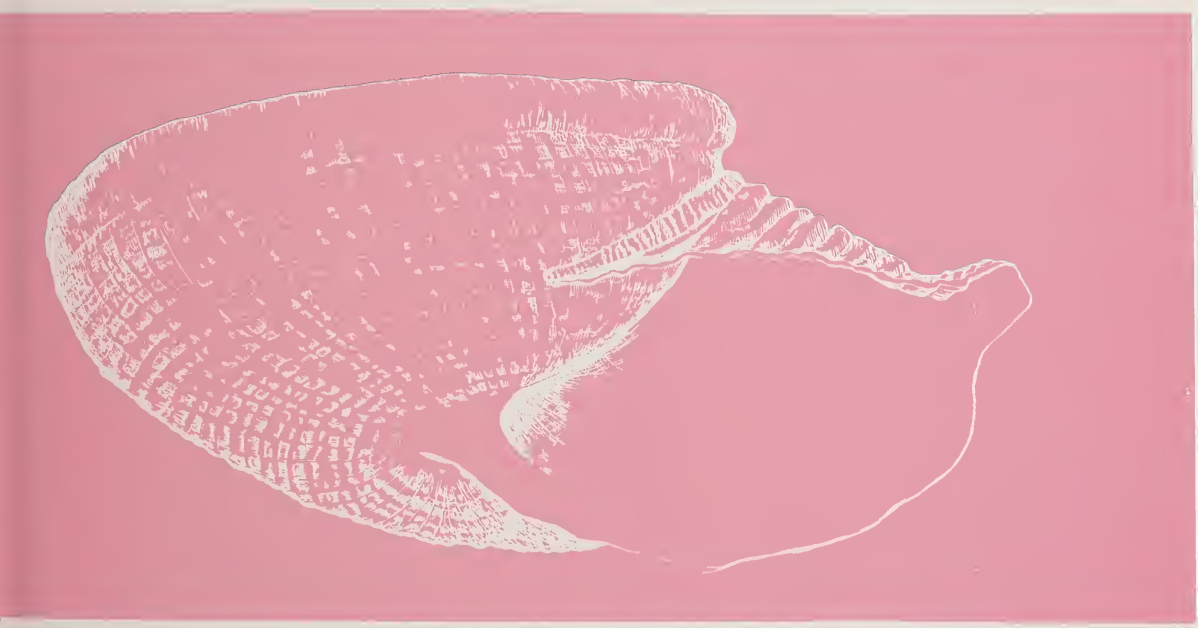

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Iberus gualtieranus (Linnaeus, 1758), una especie emblemática de la península Ibérica, que da nombre a la revista. Dibujo realizado por José Luis González Rebollar "Toza".

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A revision of the genus *Genota* H. and A. Adams, 1853 (Gastropoda; Conoidea; Borsonidae) from West Africa

Revisión del género *Genota* H. y A. Adams, 1853 (Gastropoda; Conoidea; Borsonidae) de África Occidental

Peter RYALL*, Juan HORRO** & Emilio ROLÁN***

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ABSTRACT

The West African species of the genus *Genota* are reviewed and figured, concluding that only three species are valid. Their specific characters and distribution range are commented. *Genota vafra* Sykes, 1905 is considered a junior synonym of *Genota mitriformis* (Wood, 1828); *Genota marchandi* Pin, 1996 and *Genota nigeriensis* Vera-Peláez, 2004 are considered junior synonyms of *Genota nicklesi* Knudsen, 1952.

RESUMEN

Se revisan e ilustran las especies del género *Genota* de África Occidental, concluyendo que sólo existen tres especies válidas. Se comenta su distribución y caracteres específicos. Se considera que *Genota vafra* Sykes, 1905 es sinónimo de *Genota mitriformis* (Wood, 1828), y que *Genota marchandi* Pin, 1996 y *Genota nigeriensis* Vera-Peláez, 2004 son sinónimos posteriores de *Genota nicklesi* Knudsen, 1952.

INTRODUCTION

The genus *Genota* H. & A. Adams, 1853 is endemic to the coast of West Africa and includes only a few species. NICKLÉS (1950: 129-130) indicated one species, *G. mitraeformis*, and one form "the var. *papalis*" for the area, whilst BERNARD (1984: 106) mentioned only one species in Gabon. GOFAS, PINTO AFONSO & BRANDÃO (1984: 134) recognized two species off the coast of Angola. PIN (1996) was the first to review the west African *Genota*, recognizing three species and one subspecies and describing a fourth species as new. After this publication it was generally accepted that his subspecies mentioned as "*Genota mitraeformis* subsp. *papalis* Reeve" should be elevated to full species level. This was accepted by ARDOVINI & COSSIGNANI (2004: 223). Thereafter five species were thought to inhabit this area, which were easy to identify according to the characters described by their various authors: *Genota mitriformis* (Wood, 1828), *G. papalis* (Reeve, 1843), *G. vafra* (Sykes, 1906), *G. nicklesi* Knudsen, 1952 and *G. marchandi* Pin, 1996. However there was a sixth taxon which remained generally unknown, described by VERA-PELÁEZ (2004): *Genota nigeriensis* from Nigeria.

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During the course of our studies of the West African Conoidea Fleming, 1822 the authors examined the type of *Genota nicklesi* Knudsen, 1952. We confirm that Pin (1996) misunderstood this description, confusing it with juvenile/sub-adult and uncommon forms of specimens of *Genota papalis* (Reeve, 1843) and resulting in his redescription of the species under the name *Genota marchandi*. A similar error was repeated by VERA-PELÁEZ (2004) when he used eroded and discolored shells to describe *Genota nigeriensis*.

An extensive comparison of *Genota mitriformis* and *Genota vafra* from their entire distribution range also surprised the authors with the discovery that the two "species" are in fact morphs of the same, very variable species. Among hundreds of specimens, all kinds of intermediate forms were noted, making it impossible to define conchological borders to readily and reliably establish a separation. With this evidence we can but conclude that both taxa are indeed conspecific.

The aim of this paper is to re-evaluate the valid species and outline their characters. There are three species: *G. mitriformis* (Wood, 1828), *G. papalis* (Reeve, 1843), and *G. nicklesi*, Knudsen, 1952. Their shells and protoconchs are illustrated, we figure two of their radulae, and confirm type localities, distribution ranges and summarize our conclusions.

As this is mainly a conchological study and having present the important changes recently made in the taxonomy of the different groups of Conoidea, the authors cannot reject the posibility of some future surprises based on analysis of sequence data, mainly of the mitochondrial genome. However, the differences stated until now were not supported by this kind of study.

Abbreviations

MHNS Museo de Historia Natural "Luis Iglesias" University of Santiago de Compostela, Spain.
MNHN Muséum national d'Histoire naturelle, Paris, France.
NHMUK Natural History Museum United Kingdom, London (formerly BNMH), England.
ZMUC Zoologisk Museum University of Copenhaguen, Denmark.
CGP collection of Giovani Prelle, Torino, Italy.
CHD collection Henrikas Danilia, Klaepeda, Lithuania.
CJC collection of Javier Conde, in Museo Nacional de Ciencias Naturales, Madrid, Spain.
CJH collection of Juan Horro, Vigo, Spain.
CPR collection of Peter Ryall, Maria Rain, Austria.
CSG collection of Sandro Gori, Livorno, Italy.
sp specimen alive collected
s shell empty
f fragment
j juvenile

TAXONOMIC PART

Superfamily CONOIDEA Fleming, 1822
Family BORSONIIDAE Bellardi, 1875

Genus *Genota* H. & A. Adams, 1853

Type species: *Genota mitriformis* (W. Wood, 1828) [*Murex*]. Subsequent designation by COSSMANN (1896).

H. & A. ADAMS (1853) described *Genota* as a subgenus of *Turris* with the following characters: "Shell mitriform; whorls finely cancellated; aperture longer than wide; canal not produced; outer lip with a deep posterior sinus"; they included into it *G. mitriformis* Wood and *G. papalis* Reeve. The etymol-

ogy was based on *"Le Génot"* of ADANSON (1787), being the first recognised species of the group.

FISCHER (1883: 589) elevated this taxon to genus level and made an unjustified emendation to the name as *"Genotia"*.

Genota was traditionally placed in Turridae but after the "desintegration" of this family in recent years, it was subsequently considered to belong to the family Conidae, within the subfamily Conorbinae or Clathurellinae. Finally, after radula comparison and mitocondrial analisis, BOUCHET, KANTOR, SYSOEV & PUILLANDRE (2011) included this genus in the family Borsoniidae Bellardi, 1875.

Undoubtedly, *Genota* shows a clear morphological affinity to real *Conus* from which it may be separated by its narrowly fusiform shell with high acute spire, elaborately sculptured last whorl with deep posterior sinus, and its radula exhibiting a strong, tuberculated base generally observed only in "turrids".

Genota does not have an operculum. ADANSON (1757) mentioned its presence, describing it as close to a *Conus* one. This erroneus information was copied by TRYON (1884). VON MALTZAN (1883: 118) already noted that the only live collected specimen he examined had no operculum. We believe Adanson's comment was only a supposition, because his type specimen is apparently dead taken, so we even doubt that he had ever examined an animal of this genus.

As mentioned, *Genota* is endemic to the West African area. RAYMOND (1906) used this name for West American species which are today considered in *Megasurcula* Casey, 1904. It is therefore easy to exclude similar species from other geographic areas which exhibit sufficient similarities to merit hypothetical synonymous speculation.

The genus *Genota* has a very wide distribution range in the circalittoral areas of mainland West Africa, found as far north as 25°N off the coast of Western Sahara and as far south as 15°S off Namibe, southern Angola. It is surprisingly absent from the off-shore islands in the Gulf of Guinea.

Genota mitriformis (W. Wood, 1828) (Figs. 1A-N, 4-F and 5A,B,E,F)

Le Génot Adanson, 1757: 145, pl. 9, fig. 35.
Murex mitriformis W. Wood, 1828: 15, pl. 5, fig. 25. [Type locality: «Ile de France»].
Pleurotoma mitraeformis, atributed to Valenciennes by Kiener, 1839 (pars): pl. 21, fig. 1).
Genota vafra Sykes, 1905: 317, pl. 17, fig. 9.

Type material: The type material of *Murex mitriformis* Wood could not be found (pers. com. Amelia MacLellan, from NHMUK). The unjustified emendation *Pleurotoma mitraeformis* should conserve the same type series (ICZN art. 33.2.3) as the original taxon. The type of *Le Génot* of Adanson (Figs. 1 H-I), used by KIENER (1840) for *Pleurotoma mitraeformis*, is in MNHN Paris (Typotheque Coll. Adanson n° Moll 22471). The type of *Genota vafra* is in NHMUK, reg. No. 1986119 (Figs. 1L-M).
Other material studied: Senegal: 3 s, St. Louis (CJC); 6 sp, Rufisque, 20 m (CPR); 6 sp, Gorée, 15-20 m (CPR); 3 s, Gorée (CJC); 10 sp, 4s, 4j, Baie de Hann, 15-20 m (CPR); 1 s, Dakar, 25 m (MHNS); 1 s, Dakar, 22 m (CJH); 1 s, Cap de Naz, 18 m (CJH); 7 sp, Casamance, 15-20 m (CPR). Guinea Bissau: 3 s, off Conakry (CPR). Sierre Leone: 7 s, 30-40 m (CHD). Ivory Coast: 7 sp, San Pedro, 60 m (CPR); 3 sp, San Pedro, 60 m (CJH); 9 sp, Grand Bassam, 40 m (CPR); 3 s, off Abidjan (CJC). Ghana: 22 sp, 215° off Miamia, 48 m (CPR); 12 sp, 212° off Miamia, 42 m (CPR); 4 sp, 2 j, Miamia (MHNS); 1 sp, Miamia, 25 m (CJH); 4 s, Cape Three Points (MHNS); 3 s, Cape Three Points (CJH); 26 j, off Princestown, 27 m (CPR); 9 sp, off Sekondi (CPR); 1 sp, Sekondi, 35 m (CJH); 17 sp, trawled off Shama (CPR). Cameroon: 4 s, Kribi, 10-15 m (CGP). Gabon: 3 sp, Isle Bainie, 5 m (CPR); 2 sp, Libreville, 25-30 m (CPR). Angola: 3 sp, Corimba, 20 m (CPR); 6 sp, Ilha Luanda, 40 mm (CPR); 3 j, Luanda, 30 m (CPR); 2 sp, Luanda, 40 m (CPR); 2 s, Luanda, 40 m (CJC); 3 sp, off Luanda, 35-45 m (CJH); 3 sp, Farol das Lagostas, 20 m (MHNS); 2 sp, Cacuaco, 15-20 m (CSG).

Description: The original description of WOOD (1828) consists simply of a poor drawing and the text "25 mitriformis – brown striated – Isle of France". However it was enough to recognize the species and all subsequent authors accepted this identification.

KIENER (1840: 49-50) described *Pleurotoma mitraeformis* as follows, expanding a brief Latin diagnosis.

«*Coquille allongée, fusiforme, ayant la spire pointue, moins longue que le dernier tour, et formée de neuf autres tours assez étroits dont la surface est partagée en deux parties inégales par un angle obtus garni d'une rangée de petits tubercules subpliciformes; la partie la plus étroite se trouve entre la suture et l'angle; elle est un peu concave et munie de stries très-fines; l'autre partie offre le plus souvent de petites côtes longitudinales qui sont la continuation des tubercules; la suture est linéaire, bordée d'un bourrelet légèrement arrondi; tout le reste de la coquille est couvert de grosses stries assez régulières, rapprochées, traversées par d'autres stries longitudinales et courbées, ce qui rend la surface granuleuse; le dernier tour est très-atténué à sa base; les tubercules de la carène s'y prolongent à peine. L'ouverture est fort étroite, allongée; la columelle est droite, arrondie, cylindriforme; le bord droit est mince, tranchant, muni à sa partie supérieure d'une échancrure peu profonde et subtriangulaire. Cette coquille est d'un roussâtre clair, quelquefois le haut de la spire est d'un gris cendré.*»

SYKES (1905) described his *Genota vafra* as follows: «Shell elongate, mitriform, spire well produced; apex acute; pale yellow, with brown bands; sculpture protoconch smooth, the next few whorls marked by spirals with few oblique longitudinals, the whorls slightly angulated in the middle; gradually these longitudinals become stronger, until on the penultimate whorl there is a row of nodules just below the suture, followed by a few spirals and another row of larger nodules below; the last whorl has, in addition to this sculpture, a number of smaller nodules arranged in regular spiral, as also arcuate longitudinal rows, these being continued to the base of the shell; whorls 10, plano-convex; aperture elongate, narrow, fairly straight, with a well-marked, wide notch below the suture".

The protoconch (Figs. 5A, B and 5E, F) varies from slightly more than 2 ½ whorls to almost, but not reaching, 3 whorls. The first 2 ¼ of which are absolutely smooth and the remaining portion with arcuate spiral ribs which cover all the whorl with very faint traces of spiral lines, ending with four or five very close spiral ribs, after which starts the teleoconch.

Dimensions: The holotype of *Pleurotoma mitriformis* Wood is unknown; the holotype of G. *vafra* is 31.5 mm. Average adult is around 35 mm; maximum size seen by the authors 48 mm, Libreville, Gabon. ODHNER (1922) cited 53 mm, but did not figure his specimen, so perhaps could be the bigger *papalis*. BERNARD (1984) cited 49 mm.

(Right page) Figure 1. *Genota mitriformis* (W. Wood, 1828). A: shell, 44.6 mm, Sierra Leone, 40 m (CHD); B: shell, 37 mm, Miamia, Ghana, 43 m (CPR); C: shell, 44 mm, Liberia (CPR); D: shell, 35 mm, Luanda, Angola, 40 m (CPR); E: shell, 33.1 mm, Miamia, Ghana, 38 m (CPR); F: shell, 32 mm, Ghana, 37 m (CPR); G: shell, 34.8 mm, Guinea-Bissau, 30-50 m (CJH); H, I: syntype of Adanson's "le Genot", 35.6 mm (MNHN); J, K: shells, 30.3 mm y 30.4 mm, Corimba, Luanda, Angola, 20 m (CPR); L, M: holotype of *Genota vafra* Sykes, 1905, 31.5 mm (MNHUK); N: shell, 28.7 mm, Guinea Conakry, 40 m (CHD).

(Página derecha) Figura 1. Genota mitriformis *(W. Wood, 1828). A: concha, 44,6 mm, Sierra Leona, 40 m (CHD); B: concha, 37 mm, Miamia, Ghana, 43 m (CPR); C: concha, 44 mm, Liberia (CPR); D: concha, 35 mm, Luanda, Angola, 40 m (CPR); E: concha, 33,1 mm, Miamia, Ghana, 38 m (CPR); F: concha, 32 mm, Ghana, 37 m (CPR); G: concha, 34,8 mm, Guinea-Bissau, 30-50 m (CJH); H, I: sintipo de "le Genot" de Adanson, 35,6 mm (MNHN); J, K: conchas, 30,3 mm y 30,4 mm, Corimba, Luanda, Angola, 20 m (CPR); L, M: holotipo de* Genota vafra *Sykes, 1905, 31,5 mm (MNHUK); N: concha, 28,7 mm, Guinea Conakry, 40 m (CHD).*

A
B
C
D
E
F
G
H
I
J
K
L
M
N

Animal: BOYER (1997: 33) has described the animal of *G. vafra* as «rougeatre». In our collectings it was not observed.

The radula is shown in Fig. 4-F. It agrees in all chacteristics with POWELL (1966: 96, text fig. E.126), when reproducing the one done by THIELE (1929: 572), and with BOUCHET *ET AL.* (2011). It must be remarked that our radula was extracted from a specimen with typical shell features of the *vafra* morph.

The radula has some similarity with that of Conidae species, being formed by two lines of marginal very modified teeth. In the present species the number of teeth is small (about 26). The tooth (Fig. 4F) is formed by a hollow tubular structure which channels the venom. The apex has a small barb in different possition to that in Conidae teeth. The waist is scarcely distinct. They are very small: LC/DR = 240 (in the terminology of ROLÁN & RAYBAUDI MASSILIA, 1994a).

Habitat: Only mentioned in NICKLÉS (1950: 129, "sand or mud-sandy bottom"). Our material is from mud, sand and hard bottoms between 15 and 100 m.

Distribution: From the area of St. Louis, north Senegal along the whole mainland of West Africa to Luanda, north Angola. Apparently absent in the islands of the Gulf of Guinea. The morph usually considered as *vafra* has been historically collected off Northern Senegal to Guinea Bissau but similar specimens have now been recorded throughout West Africa. Whilst NORDSIECK (1977) and NORDSIECK & GARCÍA-TALAVERA (1979) reported this species in the Canary Islands, these records are erroneous. Their descriptions and illustrations seem to agree better with G. *papalis*, which has a more northern distribution range and could have been carried by trawlers operating off the Western Sahara and Mauritania to their harbour bases in these islands. No *Genota* species appear in the most recent book on the Canary Islands (HERNÁNDEZ, ROLÁN & SWINNEN, 2011).

Remarks: This species has often been named "*mitraeformis*" and attributed to Kiener. There is no doubt that Kiener's *mitraeformis* is the same species as Wood's *mitriformis*, because Kiener himself wrote "*Wood dans son Catalogue of shells (pl. 5, fig. 5) l´a nommé Murex mitriformis*". Kiener credited the name to Valenciennes, who certainly did not describe it, and the only connection we can find is that he used to put labels in the shells of Paris Museum for his personal use or for preparation of descriptions never done before. The earlier spelling of the name *mitriformis* is the correct one.

SYKES (1905) separated G. *vafra* from G. *mitriformis* by "its less produced spire, the conspicuous rows of granules or nodules on the last whorl, and the well-marked double row of nodules on the upper whorls".

PIN (1996) separated the species with these words "*G. vafra* clearly differs from *G. mitraeformis* by its reddish colour and finer axial and spiral ribs", - character which doesn´t agree with Sykes, because finer axials and spirals origin less conspicuous granules in the intersections- as well as noting that protoconchs could "unquestionably distinguish" the two. A strange assumption as he also wrote "While not a single specimen of *G. mitraeformis*, among the hundreds we examined, had an intact protoconch...".

Recent authors also considered *mitriformis* and *vafra* as valid different species, and it seems very logical looking at the extreme morphs which are often figured under both specific names: i.e. Figs 1A and 1N.

Summarizing differences from both descriptions and from the usual concept of both morphs, the characters for separating them should be the following ones: *mitriformis*: reddish colour, longer spire with narrower shape; only one row of nodules in the middle of the whorls. While *vafra*: two rows of nodules, bigger and so less numerous granules or nodules in the last whorl and pale yellow colour.

However, the authors have concluded that (lacking DNA data) there is no real separation between these mor-

Figure 2. *Genota papalis* (Reeve, 1843). A: shell, 53.5 mm, Kayar, Senegal, 100 m (CPR); B: shell, 30.5 mm, Farol das Lagostas, Luanda, Angola, 40 m (CPR); C: shell, 42.9 mm, Elmina, Ghana, 60 m (CPR); D: shell, 48.2 mm, Cape Barbas, West Sahara, 70 m (CPR); E, F: shell, 24.5 mm, Cacuaco, Luanda, 30 m (CPR); G: shell, 41.5 mm, Casamance, Senegal, 30 m (CPR); H: shell, 46.2 mm, Guinea Conakry, 35 m (CHD); I: shell, 31.8 mm, Hann Bay, Dakar, Senegal, 30 m (CPR); J: shell, 28.5 mm, Mauritania, 35 m (CPR); K: shell, 30 mm, Luanda, Angola, 40 m (CPR).

Figura 2. Genota papalis *(Reeve, 1843). A: concha, 53,5 mm, Kayar, Senegal, 100 m (CPR); B: concha, 30,5 mm, Farol das Lagostas, Luanda, Angola, 40 m (CPR); C: shell, 42,9 mm, Elmina, Ghana, 60 m (CPR); D: concha, 48,2 mm, Cabo Barbas, Sahara occidental, 70 m (CPR); E, F: concha, 24,5 mm, Cacuaco, Luanda, Angola, 30 m (CPR); G: concha, 41,5 mm, Casamance, Senegal, 30 m (CPR); H: concha, 46,2 mm, Guinea Conakry, 35 m (CHD); I: concha, 31,8 mm, Bahía de Hann, Dakar, Senegal, 30 m (CPR); J: concha, 28,5 mm, Mauritania, 35 m (CPR); K: concha, 30 mm, Luanda, Angola, 40 m (CPR).*

Table I. Basic measurements for the specimens illustrated on Figure 1, ordered from lowest to highest length/width ratio. *v: type specimen of *Genota vafra;* *m: Adanson's specimen, figured by KIENER (1839) as *Genota mitraeformis.*
*Table I. Mediciones de los especimenes ilustrados en la Figura 1, ordenados de menor a mayor índice longitud/anchura. *v: especimen tipo de* Genota vafra*; *m: especimen de Adanson, ilustrado por KIENER (1839) como* Genota mitraeformis.

ratio length/width	ratio mouth/spire
2.75 (Fig. 1N)	1.75 (Fig. 1N)
2.91 (Fig. 1K)	
3.01 (Fig. 1L, *v)	
3.16 (Fig. 1H, *m)	1.68 (Fig. 1H, *m)
3.18 (Fig. 1J),	
3.26 (Fig. 1D)	
3.38 (Fig. 1G)	1.5 (Fig. 1F
3.48 (Fig. 1F)	1.36 (Fig. 1G)
3.54 (Fig. 1C)	1.25 (Fig. 1C)
3.78 (Fig. 1A)	1.09 (Fig. 1B)
3.83 (Fig. 1B)	0.95 (Fig. 1A)

phospecies, because, as it is shown in the comparative plate there are enough intermediate morphs to question if those conchological characters separate them: it is posible to find shells with well-marked double row of nodules but also shells with a less marked upper row of nodules and with only a lower one, and this feature does not correspond with the size of the granules and nodules in the last whorl or with the size of the spire. In fact, when a long sample of specimens from different origins is put together, it is almost imposible to agree where the shells start with or without those characters. Even more, checking Adanson's type of *Le Génot*, it is closer to *vafra* description, because it shows the double row of nodules and more conspicuous nodules in the last whorl than usual.

The ratio length/width measured in all specimens studied goes from 2.75 (Fig. 1N) to 3.83 (Fig. 1B). At first sight it seems too much for a single species, but all kinds of intermediates measurements are found without a separation border (Table I) The same happens when measuring ratio mouth/spire, which offers a degree of variation from 0.95 (Fig. 1A) to 1.75 (Fig. 1N), with all intermediates. It must be remarked that although usually the bigger is the first measurement the lower is the second: 3.78-0.95 (Fig. 1A) while 2.75-1.75 (Fig. 1N); it doesn´t happen thus in many specimens, i.e.: 3.48-1.5 (Fig. 1F) while: 3.38-1.36 (Fig. 1G).

Regarding rows of nodules on the spire, there are shells with two clear rows of large nodules corresponding to usual morph *vafra* (Figs. 1L-N), but also some closer to usual considered *mitriformis* (Fig. 1G), there are shells with two rows of nodules but the upper one less developed, some of them absolutely out of *vafra* concept (Figs. 1E and 1F), and there are also shells clearly into morph *vafra*, which only presents one row of nodules, showing in the upper part a subsutural cord like usual *mitriformis* (Figs. 1J-K).

- size and number of granules in last whorl: the number of spiral bands in the body whorl, without including the little ones in the fasciole, varies from 15 to 19 in all specimens studied, and it doesn´t keep a relationship with the shape of the shell (Fig. 1A has the same number that Fig. 1N). As they are crossed by axials which seems to correspond with shell growth, they always form nodules, and,

Figure 3. *Genota nicklesi* Knudsen, 1952. A, B: holotype, 32 mm (ZMUC); C, D: topotype of *Genota marchandi*, 43 mm, Casamance, Senegal, 15 m (CPR); E: holotype of *Genota marchandi*, 40.9 mm (MNHN); F, G: shell, 39.1 mm, Takoradi, Ghana, 12 m (CPR); H, I: juvenile, 21.2 mm, Cacuaco, Angola (CPR); J: shell, 47.5 mm, S. Pedro, Ivory Coast (CPR); K: shell, 41.4 mm, Vridi, Ivory Coast, 30 m (CPR); L-N: topotypes of *Genota nigeriensis*, 23.5, 19.8 and 25.8 mm, Lagos, Nigeria (CJC).
Figura 3. Genota nicklesi *Knudsen, 1952. A, B: holotipo, 32 mm (ZMUC); C, D: topotipo de* Genota marchandi, *43 mm, Casamance, Senegal, 15 m (CPR); E: holotipo de* Genota marchandi, *40,9 mm (MNHN); F, G: concha, 39,1 mm, Takoradi, Ghana, 12 m (CPR); H, I: juvenil, 21,2 mm, Cacuaco, Angola (CPR); J: concha, 47,5 mm, S. Pedro, Costa de Marfil (CPR); K: concha, 41,4 mm, Vridi, Costa de Marfil, 30 m (CPR); L-N: topotipos de* Genota nigeriensis, *23,5, 19,8 and 25,8 mm, Lagos, Nigeria (CJC).*

the less numerous the axials are, the bigger the nodules seem, but similar size of nodules can be found both in typical *vafra* morph and in *mitriformis* morph (compare Figs. 1A or 1E with the type of *vafra*).

- colour: shells vary from pale cream or pale yellow to reddish or brownish and even dark brown, usually with outer lip white or almost white and with lighter spiral bands not clearly marked in the body whorl. No real difference according to shape of the shell can be seriously stated.

Undoubtedly, although we believe that the images are clear, this opinion could be a wrong personal opinion of the authors. However we must also consider the following more objective data:

- protoconch is absolutely impossible to be differentiated (Figs. 5A and 5F are from a typical *vafra* and Figs. 5B and 5E from a typical *mitriformis*).
- radula is identical in both morphs as already was mentioned.
- after checking shells from different places and bathymetric ranges it is also impossible to set clear habitat separation.

Thus, we believe that the only logical conclusion is to admit that they may be conspecific morphs of a very variable species.

Genota papalis (Reeve, 1843) (Figs. 2A-K and Fig. 5C)

Pleurotoma mitraeformis (unnamed variety) - Kiener, 1839: pl. 21, fig. 1a (only).
Pleurotoma papalis Reeve, 1843: pl. 4, sp. 22. [Type locality: not designate].
Genota nicklesi of AA, sensu Pin, 1996, non Knudsen, 1952.

Type material: Reeve´s type, described from Stainforth's collection is supposed to be in NHMUK, but could not be found.
Other material studied: Western Sahara: 3 sp, 2 j, 40 m (CPR); 3 sp, Dakhla, 50-60 m (CPR); 2 s, 30-40 m (CJH). Mauritania: 1 sp, off Nouahdhibou, 30 m (MHNS); 1 j, 2 sp, off Nouakchott, 40-50 m (CPR). Senegal: 1 sp, Kayar, 100 m (CPR); 3 s, Baie de Gorée, 15 m (CPR); 6 sps, Baie de Hann, 15-20 m (CPR); 1 j, 3 sp, Casamance, 10 m (CPR); 2 sp, 2 j, Dakar (CJH); 1 sp, 1 j, Dakar (MHNS); 3 sp, Dakar (CJC). Ivory Coast: 1 sp, San Pedro, 60 m (CPR); 1 j, off Abidjan, 40 m (CPR). Ghana: 1 j, Adjua, 50 m (CPR); 2 j, 210° off Miamia Bay, 45 m (CPR); 2 sp, off Elmina, 60 m (CPR). Angola: 6 sp, Luanda, 40 m (CPR); 4 sp, Luanda (CJC); 3 sp, Luanda, 25-35 m (CJH); 1 j, Cacuaco, 20 m (MHNS); 1 j, south Luanda, 60 m (MHNS); 2 j, Mutuco (MHNS); 5 sp, Ilha de Luanda, 50-60 m (CPR); 6 sp, Corimba, 35 m (CPR); 6 j, Corimba, 25 m (CPR).

Description: Original description (Reeve, 1843): "Shell fusiform, sharply turrited, pale yellowish brown; whorls concave round the upper part, longitudinally lightly ridged, ridges numerous, last whorl encircled with a pale band, canal short."

Kiener (1840) wrote in *Pleurotoma mitraeformis "La variété qui est représentée dans notre pl. 21, fig. 2, est remarquable par sa forme un peu plus renflée et par une zone blanchâtre qui traverse son dernier tour"*.

To complete those short descriptions, we add the following: Protoconch paucispiral with slightly more than one to one and a half whorls, rounded with nucleus inclined, smooth although showing traces of spiral lines, developing in its final part arcuate spiral ribs which cover all the whorl, well-marked transition to teleoconch, which is composed of 6/7 whorls in adult stage. It starts usually along the first two whorls with strong arcuate ribs, which by about the third whorl cover only the lower part of the whorl making it angulated in the middle, and soon turn into nodules which form a strong shoulder leaving a concave to very concave subsutural part, with a more or less marked subsutural ridge not axially sculpture and never forming nodules. In last whorl, sometimes the axial sculpture gets finer and tends to be

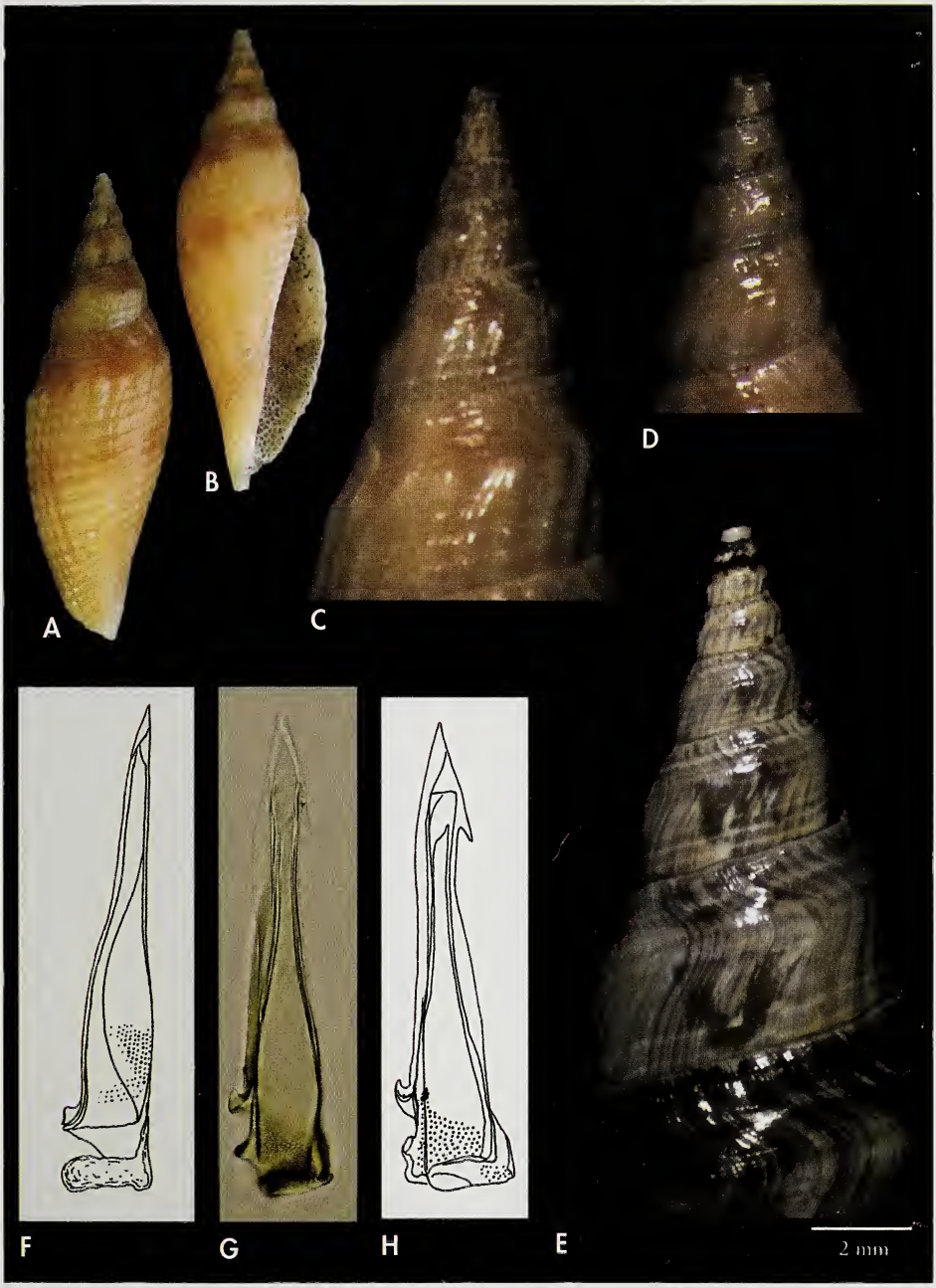

Figure 4. A, B: *Genota nicklesi*, shell, 17.8 mm, Kribi, Cameroon, 15 m (CGP). C-E: apex. C: *Genota nicklesi*, Casamance, Senegal, topotype of *G. marchandi* (CPR); D: *Genota nicklesi*, Lagos, Nigeria, topotype of *G. nigeriensis* (CJC); E: holotype of *Genota nicklesi* (ZMUC). F-H: radular teeth. F: *Genota mitriformis*, drawing; G, H: *Genota nicklesi*, optical photograph and drawing.
Figura 4. A, B: Genota nicklesi, *concha, 17,8 mm, Kribi, Camerún, 15 m (CGP). C-E: ápices. C:* Genota nicklesi, *Casamance, Senegal, topotipo de* G. marchandi *(CPR); D:* Genota nicklesi, *Lagos, Nigeria, topotipo de* G. nigeriensis *(CJC); E: holotipo de* Genota nicklesi *(ZMUC). F-H: dientes radulares. F:* Genota mitriformis, *dibujo; G, H:* Genota nicklesi, *fotografía óptica y dibujo.*

attenuated, but it is always present, very strong almost as axial costae in some specimens. Spiral sculpture of homogeneous incised lines all along the complete surface of the shell, closer ones in the subsutural band including the ridge than in the lower part of the shell. They reach a number of 45 to 55 lines in the body whorl. In specimens with more marked axials, they give the shell a reticulated appearance, but never form real nodules. Aperture long and narrow, with arcuate columella, covered with parietal callus in the adult stage. Sinus U-shaped. Protoconch from white to reddish colour. Typical teleoconch colour is cream, with blotches and spots of dark brown and white usually arranged in spiral bands, with light shoulder nodules and white in all the mouth, from parietal callus to outer lip, also white in its exterior part.

Dimensions: Holotype unknown; average size around 42-45 mm; maximum size seen by the authors 53.28 mm, off Dakla, Western Sahara. Ardovini & Cossignani (2004: 223) figured a specimen of 55 mm, from Guinea Bissau.

Animal: Boyer (1997: 33) described an immature specimen collected at Gorée as "plus claire et bicolore"; it was wrongly identified as *G. nicklesi*.

Habitat: This species has the deepest habitat of the *Genota* species which may account for its absence in the Niger/Congo delta areas of West Africa. After the information in Maltzan (1883: 117), Pin (1996: 54) and Boyer (1997: 33) and our own information, the species lives between 10 and 200 m.

Distribution: The species is known from the area of Cape Barbas, Western Sahara along the mainland of West Africa to Guinea Bissau. Scarce in the Gulf of Guinea with few specimens from Ivory Coast and Ghana and so far not recorded from the Niger/Congo Deltas but appears again around Luanda, north Angola. Absent in the islands of the Gulf of Guinea. We already commented on its supposed presence in the Canary Islands.

Remarks: There are some varieties, specially in its southern distribution range, where can be found specimens with more turrited spire and slender shell, very marked sculpture or specimens with bigger nodules at the shoulder and also very marked sculpture, all of them usually uniform very light cream or light orange/brown colour (Figs 2B and 2E-F) however they agree in most features with typical shells and so these differences don´t seem to have specific or even subspecific value.

We find it strange that many of the earlier authors considered *G. papalis* only a variety of *G. mitriformis*, because, apart from all other specific characters, its protoconch is absolutely different, the only paucispiral one in the genus.

It is also somewhat strange that in spite of this paucispiral protoconch, this species has such a wide geographic range, because paucispiral species usually have more restricted distribution. Due to this, we have checked shells with distant origins, and (always lacking DNA analysis) it seems clear that there are no separable geographic morphs.

The variety known as *Genota nicklesi* of AA after Pin is not a different species, but *papalis* with a different protoconch colour, finer spiral ribs and absence of nodules when crossing the axial ribs. These characters have no specific value, because it is easy to find a big degree of colour variation in the same populations, not only in the adult shell but also in the protoconch. Pin (1996) refers this supposed species to a reddish protoconch, but there are whitish, reddish and intermediate coloured protoconchs without any correspondence with the other characters of the shell, which can be more or less sculptured or smooth and have more or less fine spiral ribs without relationship with that colour. Fig. 2K illustrates a specimen with dark red protoconch showing all characters atributed to *G. papalis* by Pin, while Fig. 2J illustrates a young shell with white protoconch which agree with the ones atributed to his "*nicklesi*".

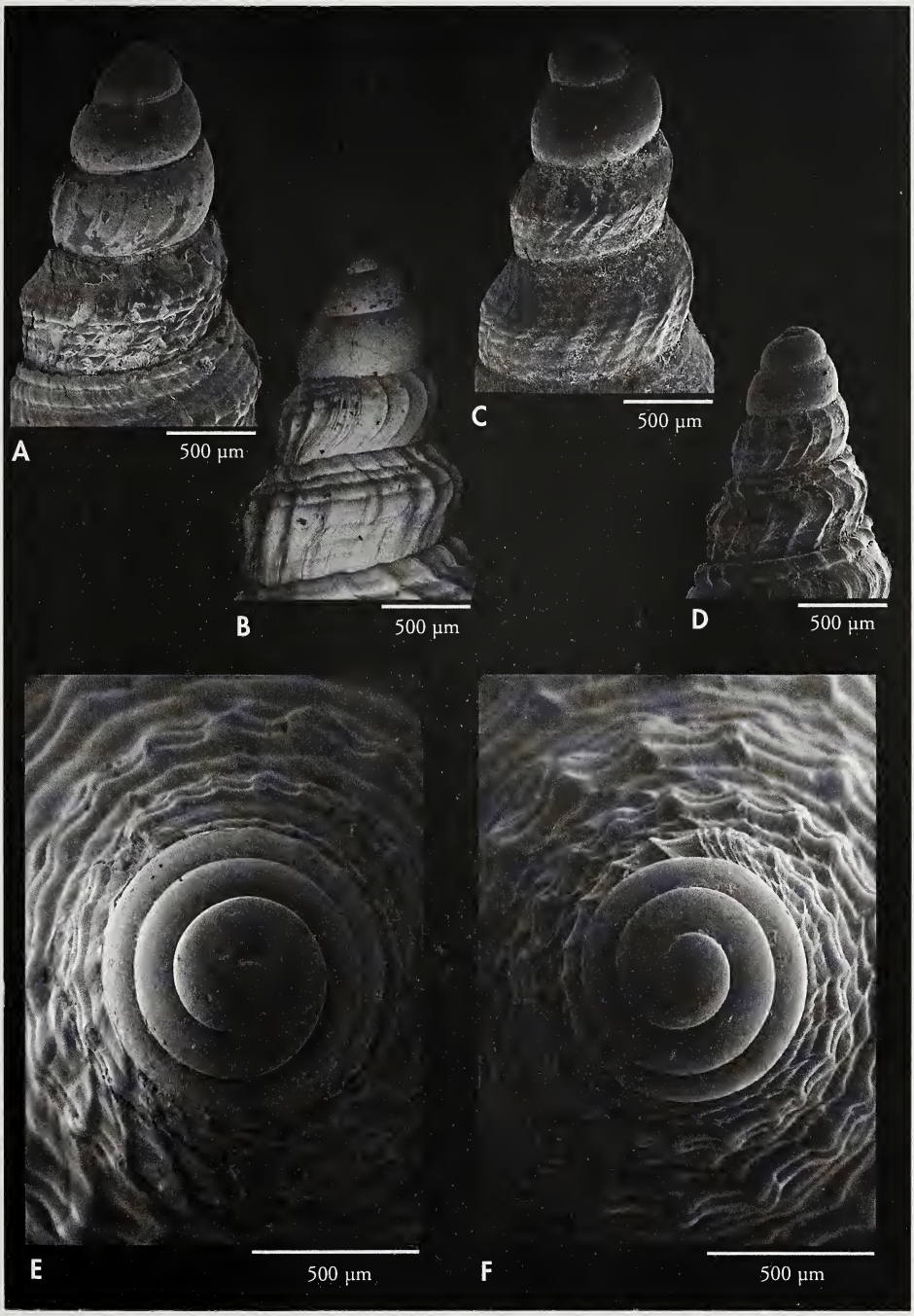

Figure 5. *Genota* protoconchs. A: *Genota mitriformis*, "morph *vafra*", lateral view; B: *Genota mitriformis*, lateral view; C: *Genota papalis*, lateral view; D: *Genota nicklesi*, lateral view; E: *Genota mitriformis*, apical view; F: *Genota mitriformis*, "morph *vafra*", apical view.

Figura 5. Protoconchas de Genota. *A:* Genota mitriformis, *"morfotipo vafra", vista lateral; B:* Genota mitriformis, *vista lateral; C:* Genota papalis, *vista lateral; D:* Genota nicklesi, *vista lateral; E:* Genota mitriformis, *vista apical; F:* Genota mitriformis, *"morfotipo vafra", vista apical.*

Genota nicklesi Knudsen, 1952 (Figs. 3A-N, 4A-E, 4G, 4H and 5D)

Genota nicklesi Knudsen, 1952: 176, pl. 1, fig. 12. [Type locality: 5°58'S-12°8'E, off Angola, West Africa, 26 m, mud bottom].
Genota marchandi Pin, 1996: 55, figs. 10-13. [Type locality: Senegal].
Genota nigeriensis Vera-Peláez, 2004: 99, figs. 9-14. [Type locality: Nigeria].
Genota marchadi (misspelling) - Ardovini & Cossignani, 2004: 37, fig. 222.

Type material: Holotype in ZMUC, from Atlantidae collection (Figs 3A, 3B, 4E). Holotype of *G. marchandi* is in MNHN (Fig. 3E) and one of the authors (CPR) has a shell that came from the topotype material of Pin's 31 shells (Figs. 3C, 3D, 4C) with number 14 in Pin's own handwriting. We were not allowed to study the holotype or paratypes of *nigeriensis* in the Museo Paleontológico of Estepona, Spain, but have examined the specimens in CJC, cited as "topotypes" in the description paper (five specimens, Figs. 3L-N, 4D).
Other material studied: Senegal: 1 sp, Casamance, 15 m (CPR); 1 sp, Casamance (CJH); 2 s, Dakar (CJH). Guinea-Bissau: 2 sp, 30 m (CJH). Ivory Coast: 6 sp, off San Pedro, 35-45 m (CPR); 5 sp, in Vridi Canal, Abidjan, 25-30 m (CPR). Ghana: 3 sp, Mudrachmi Bay, 30-40 m (CPR); 12 j, in front River Nyang estuary, 12-15 m (CPR); 1 s, Miamia, 18 m (CJH); 2 j, Miamia (MHNS); 8 sp, Takoradi harbour, 15-25 m (CPR); 15 sp, off Elmina, 30-50 m (CPR). Nigeria: 5 sp, off Lagos (CJC). Cameroon: 2 s, Kribi, 10-15 m (CGP). Gabon: 2 sp, 20 m (CJC). Congo: 3 sp, off Pointe Noire, 8-10 m (CPR). Angola: 27 sp, Farol das Lagostas, 20 m (CPR); 2 s, Farol das Lagostas, 20 m (CJC); 2 sps, 4 j, Farol das Lagostas, 5-20 m (MHNS); 4 sp, 12 j, Cacuaco, 5-8 m (CPR); 2 s, 7 j, Cacuaco, 15-20 m (MHNS); 2 sp, Cacuaco, 15-20 m (CJH); 5 sp, off Luanda, 40 m (CPR); 3 j, off Luanda, 50 m (MHNS); 1 sp, Luanda, 20 m (CJC); 3 j, Luanda, 25 m (MHNS).

Description: Original description (Knudsen, 1952): "Shell of the typical appearance of the genus *Genota*. About 9 whorls are present. The protoconch has 3 smooth light brown whorls. On the uppermost part of the adult shell an axial sculpture of oblique ribs is seen. These whorls are distinctly shouldered. About the sixth whorl the ribs gradually become obsolete, so that the only axial sculpture is the numerous growth lines. At the same time also the shoulder tend to disappear, but can be detected as a faint rounded edge even on the body whorl. This edge forms the lower limit of the subsutural band. A spiral sculpture is seen right from the uppermost part of the adult shell, where 3 regularly incised lines are present. Further down this number gradually increases. One line near the upper suture tends to become more distinct, and two-three lines above the lower suture are more conspicuous than the lines in the middle of the whorl. The body whorl has about 25 spiral lines placed at regular intervals from below the subsutural band to the end of the siphonal canal. Aperture long and narrow, the outer lip light brown. Columella slightly concave. Outer edge crenulated, almost straight. Sinus broad and deep, situated at some distance from the suture. Colour varies from light to darker brown, with some shells tending to orange-brown, showing always darker axial flames, and is always darker in the subsutural band, with the nodules much more lighter, when present. Interior of the aperture is uniformly brown. Holotype is 32 x 9.2 mm."

Dimensions: As mentioned in the original description holotype is 32 mm, slightly subadult. Average size larger than type, maximum size seen by the authors 48,56 mm, off Elmina, Ghana. Pin´s mentions that paratype 3 of *marchandi* is 49,7 mm, but he figures six shells smaller, one of them with n° 3 written.

Specimens in Angola are generally smaller but we have seen a specimen of 45.3 mm from Cacuaco (CSG).

Soft parts not recorded: The illustration by Boyer (1997: 35) under this name is erroneous as it is a specimen of *G. papalis*.

Radula: The radula has been figured under the name "*G. marchadi* Pin, 1993" in Rolán & Raybaudi Massilia (1994b: 20, fig. 6a). We reproduce the image here (Fig. 4G, 4H). Radular teeth with a

remote similarity to those of the *Conus* species. Relatively small (LC/DR = 90), an apical barb, and different structure seen by transparence.

Habitat: The species has been collected between 5 and 40 m, in sandy bottom.

Distribution: From the area of Casamance, south Senegal along the whole mainland of West Africa to Luanda, north Angola. Absent in the islands of the Gulf of Guinea. Well represented throughout its range.

Remarks: We must add that in many specimens axial sculpture does not become obsolete as in the type, but continues all along the whorls, although it always disappears on the subsutural band in the penultimate and last whorls, in which it is smooth or shows only spirals. The same happens with the shoulder, usually present and very often forming nodules more or less marked, although it is possible to find very smooth specimens even in juvenile stages (like Fig. 3H-I). Sinus also presents different broadness and depth.

Although KNUDSEN (1952) mentioned that the protoconch had 3 smooth whorls it was not possible to check how he counted them, because nowadays it is broken in the holotype and he described the species only upon one specimen. It doesn't reach that number in any of the specimens studied, having only 2 to 2 ¼ whorls, similar to that of *G. mitriformis* but smaller and shorter; it also develops arcuate spiral ribs covering all the whorl before the beginning of the teleoconch.

Pin's interpretation of this species, which has been and still is followed by many authors and collectors (as it is easy to confirm looking at the web for images under this name), was wrong without doubt if we compare the holotype to the shells that he figured and his description.

Although Pin's description was not published until 1996, he made available specimens under his manuscript name some years earlier. For this reason some authors like ROLÁN & RAYBAUDI MASSILIA (1994b: 19) were able to mention the name *Genota marchandi* before the name had actually been published. It is also worth-while to remember that Pin named his species after Professor Bernard Marchand at the University of Dakar. It has often subsequently been misspelled as *"marchadi"*, by some authors, e.g. ARDOVINI & COSSIGNANI (2004: 37, fig. 222).

VERA-PELÁEZ (2004) described as a different species *Genota nigeriensis*, indicating that the most similar was *G. nicklesi*, although, as was usual, he used the name *marchandi* for this species. As already noted, we were denied permission to borrow the type specimens but have examined the "topotypes" specimens in CJC. They are beached and discoloured shells with eroded protoconchs (as is shown in the mentioned figures and as can also be inferred from the holotype protoconch photograph published with the description), which match perfectly into the range variation of *G. nicklesi*, not so homogeneus as is written by that author. Thus, the supposed smaller size is due to subadult condition of the specimens, as the number of whorls show; the supposed differences in the protoconch are a consequence of its eroded condition, the colour seems the typical discolored one after erosion and exposal to the sun, and other features attributed to *nicklesi* in the description paper of *nigeriensis* do not agree with many specimens, as the "wider and deeper anal sinus" or the absence of axial sculpture with prevalence of spirals in the body whorl. We show another similar dead-taken juvenile specimen from Cameroon (Figs. 4A-B) for comparison.

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Two new records of octopods in Canary Islands: *Amphioctopus burryi* (Voss, 1950) and *Macrotritopus defilippi* (Vérany, 1851) [Cephalopoda: Octopodidae]

Dos nuevos registros de pulpos en las islas Canarias: *Amphioctopus burryi* (Voss, 1950) and *Macrotritopus defilippi* (Vérany, 1851) [Cephalopoda: Octopodidae]

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ABSTRACT

This paper reports two species of octopods from the Canary Islands for the first time: *Amphioctopus burryi*, and *Macrotritopus defilippi*. Two specimens, one for each species, were caught by scuba diving in Tenerife Island. Morphological and morphometric characteristics and information on habitat, biology and geographical distribution of the two species are given. The specimen of *M. defilippi* was filmed. In a 17 seconds video record the animal displayed a "flamboyant pattern" while walking on the substrate supported on its arms fleeing the diver. As far as we know, this is the first time that the species is filmed in its natural habitat.

RESUMEN

En este artículo se reportan por primera vez dos nuevos registros de pulpos en las Islas Canarias: *Amphioctopus burryi*, and *Macrotritopus defilippi*. Se capturó un ejemplar de cada especie mediante buceo autónomo en la isla de Tenerife. Se proporciona información sobre el hábitat, biología y distribución geográfica de ambas especies. El ejemplar de *M. defilippi* fue filmado, y, en un registro de video de 17 segundos, mostró una "pauta llamativa" mientras caminaba sobre el sustrato apoyado sobre sus brazos tratando de huir del buceador. Hasta donde conocemos, esta es la primera vez que se filma la especie en su medio natural.

INTRODUCTION

The Canary Islands were not included in the first review of the cephalopods for the Iberian Peninsula (GUERRA, 1992). The reason was that this archipelago lies outside the Western Mediterranean Sea and the Mediterranean outflow faunistic provinces defined by BAKUS, HAEDRICH AND ROBINSON (1977), which were the ones considered in that review. Nevertheless, the octopod species *Macrotritopus defilippi* (as *Octopus defilippi*) was recorded in the Iberian Peninsula waters (GUERRA, 1992; GUERRA AND ROCHA, 2011). Afterwards, that species and *Amphioctopus*

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Table I. Biometric data of *A. burryi* and *M. defilippi* off the Canary Islands. TL: total length (mm), DML: dorsal mantle length (mm), VML: ventral mantle length (mm), HL: head length (mm), HW: head width (mm), FL: funnel length (mm), FW: funnel width (mm), ALI-IV: arm length I-IV (mm), LL: Ligula length (mm), W: Weight (g), S: Sex.
Tabla I. Datos biométricos de A. burryi y M. defilippi de las Islas Canarias. TL: longitud total (mm); DML: longitud dorsal del manto (mm); VML: longitud ventral del manto (mm); HL: longitud de la cabeza (mm); HW: anchura de la cabeza (mm); FL: longitud del sifón (mm); FW: anchura del sifón (mm); ALI-IV: longitud de los brazos (mm); LL: longitud de la lígula (mm); P: peso total (g), S: sexo.

	A. burryi	*M. defilippi*	Observations
TL	210	430	
DML	66	41	
VML	40	27	
HL	21	19	Dorsal
HW	20	13	Dorsal
FL	18	11	
FW	12	9	
ALI	120 (115)	107 (141)	Left (Right)
ALII	136 (128)	160 (159)	"
ALIII	132 (137)	328 (159)	"
ALIV	133 (128)	230 (256)	"
LL	—	3	
W	50,2	15,0	
S	Female	Male	

burryi were also not included in the catalogue of marine species for the Canary Islands because they were not reliably recorded in this archipelago (Guerra, Hernández and Domínguez, 2003). Recently, both species are considered present in the Canary Islands in the FAO guide for Atlantic African waters cephalopod species. The reason for this was that the first author (A.G) had news of these records during the correction of the last version of that guide (Guerra, González, Jereb and Roeleveld, in press).

After the Hawaiian Islands, the Canary Islands are probably the best studied volcanic island system in the world, both in terms of their geological history and the phylogenetic origin of their biota (see Sanmartin, Van Der Mark and Ronquist, 2008 and the references therein). Within the Macaronesian province, the marine life found in the Canary Islands is interesting, being a combination of North Atlantic, Mediterranean, and endemic species. Although the list of marine species of other groups of mollusks is relatively long (Moro, Martín, Garrido and Izquierdo, 2003), the teuthofauna of this archipelago only comprise 80 species and only 6 of them are incirrate octopods (Guerra, González, Jereb and Roeleveld, 2003). In recent years, the increasing popularity of both scuba diving and underwater photography has provided biologists with much new information about the marine life of the islands.

The aim of the present work is to present two new records of benthic octopods offering also the main information on their habitat, biology and geographical distribution, which are still poorly known.

MATERIAL AND METHODS

Two specimens were caught in the waters of the island of Tenerife, Canary Islands during the project of the ONG Iberian Biodiversity that aims to photograph and describe the marine flora and fauna.

RESULTS

Systematics

Much of the higher classification of recent cephalopods is unstable. Various authors have suggested highly varying arrangements. We adopt the conservative arrangement followed by YOUNG, VECCHIONE AND MANGOLD (2010). On the other hand, the taxonomy of the family Octopodidae is in a thoroughly unsettled state, due to several reasons (see GUERRA *ET AL.* 2013). Many species previously placed in the genus *Octopus*, recently have been allocated to other genera (see NORMAN AND HOCHBERG, 2005).

Measurements and morphological characters

Table I shows the main measurements obtained for the two specimens studied. The dimensions in all cases are in millimetres (mm) and weights in grams (g). The terminology used was proposed by ROPER AND VOSS (1963). Morphological characters of the two species studied are consistent with those given by ROPER, SWEENEY AND NAUEN (1984), NESIS (1987), VOIGHT (1998), VOSS AND TOLL (1998) for *A. burryi*, and LOZANO Y REY (1905), MAGAZ (1934), ROPER *ET AL.* (1984), NESIS (1987), GUERRA (1992), MANGOLD (1998) for *M. defilippi*.

Family OCTOPODIDAE d`Orbigny, 1839
Subfamily OCTOPODINAE d´Orbigny, 1839
Genus *Amphioctopus* P. Fischer, 1882

Amphioctopus burryi (Voss, 1950) (Fig. 1)

Most frequent synonyms:
Octopus burryi Voss, 1950. *Revista de la Sociedad Malacológica "Carlos de la Torre"*, 7 (2): 76-79 (Type locality: Florida, USA).
Octopus vincenti Pickford, 1955. *Bull. Brit. Mus (Nat. Hist.), Zoology*: 3(3): 151.

Material examined: Radazul, east coast of Tenerife island (28° 24′ 03′′ N and 16° 19′ 33′′ W), captured on May 3rd, 2011, 1 female, 210 mm in total length and 50. 2 g of total weight; captured SCUBA diving at 17 m depth on sandy bottom. This species was observed on 4 out of 30 night dives made in this location during the year 2011. Preserved with formaldehyde solution 4% buffered (pH 6.9), and deposited in the collection of the Museum of Natural Sciences in Santa Cruz de Tenerife with reference TFMCBM/11309; MO/05139. María B. Caro and M.J. Sealey leg.

Diagnostic characters: Animals of small to moderate size. Up to 70 mm mantle length. Mantle, arms and head densely covered with closely set small round papillae, whose colour is dark-blue to purplish brown, forming bands along dorsolateral surface of each arm. Head moderately small. Eyes large and with a tiny papilla over each eye-ball. Funnel organ W-shaped. Moderately long arms, the third right arm (III) in male hectocotylized. The ligula is short (4 to 6% of the hectocotylized arm length). The calamus has a deep groove with around 15 small flakes. Gill lamellae 8-11 per outer demibranch. Web in side with white reticulated stripes on red background.

Habitat and biology: A benthic species taken on sandy bottoms, often covered by broken coral and shells, from 0 to 200 m on the lower part of the continental shelf. Members of this species perform fast, efficient burying manoeuvres to hide and are ambush predators. The life cycle is estimated to range from 8 to 10 months at water temperatures ranging from 22° to 25°C. Females produce about 35 000 eggs. Egg length ranges from 2 to 2.5 mm. Females carry their eggs during the embryonic development (FORSYTHE AND HANLON, 1985; HANLON AND HIXON, 1980; GUERRA, 1992).

Distribution: Tropical eastern and western Atlantic: from Georgia to the

Gulf of Mexico, Caribbean Sea and northern Brazil (VECCHIONE, 2002), and off western Africa, Senegal and Cape Verde Islands to Angola (GUERRA *ET AL.*, 2013).

Family OCTOPODIDAE d'Orbigny, 1839
Subfamily OCTOPODINAE d'Orbigny, 1839
Genus *Macrotritopus* Grimpe, 1922
Macrotritopus defilippi (Vérany, 1851) (Fig. 2)

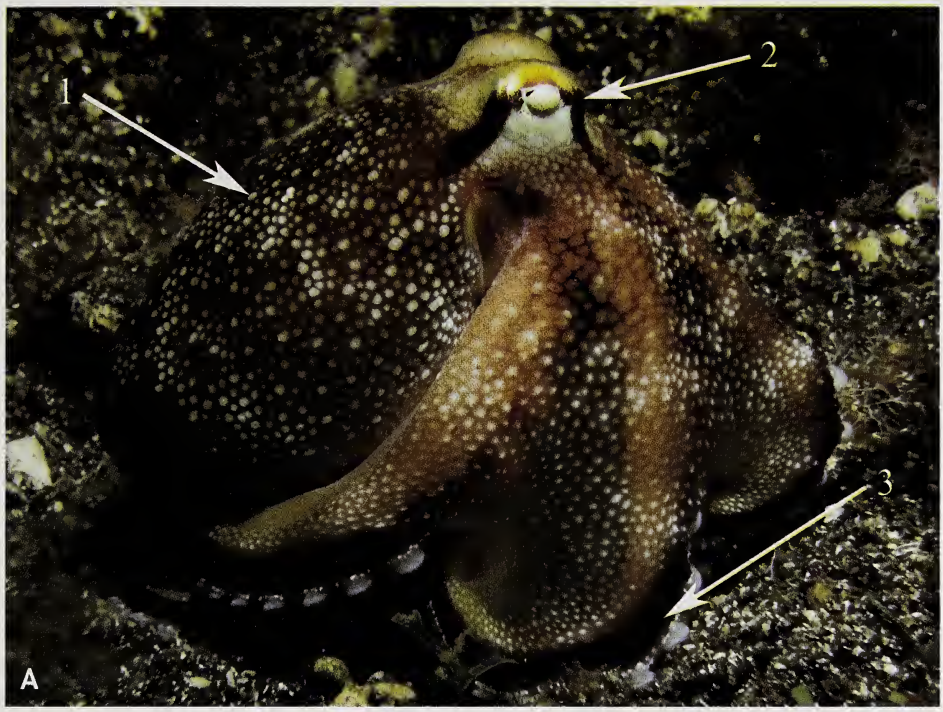
Most frequent synonyms:
Octopus defilippi Vérany, 1851. *Moll. Médit.*, 1. *Gênes*: 30 (Type locality: Western Mediterranean Sea).
Macrotritopus kempi (Robson, 1929). *Ann. Mag. Nat. Hist.*, 10(3): 311-313.
Macrotritopus danae (Joubin & Robson, 1929). *Proc. Zool. Soc. London*, 1929(1): 89-94.

Material examined: Tabaiba, east coast of Tenerife island (28° 24′ 04″ N and 16° 19′ 53″ W), captured on May 4th , 2011, 1 male specimen, 430 mm in total length and 15.0 g total weight; captured SCUBA diving at 15 m depth on sandy bottom. The specimen was filmed. In a 17 seconds video record the animal displayed a "flamboyant pattern" (HANLON AND MESSENGER, 1996) while walking on the substrate supported on its arms fleeing the diver. The video is available in the Flickr web under the following URL <http://flic.kr/p/ec9N2>. As far as we know, this is the first time that the species is filmed in its natural habitat. This species was observed on 2 out of 30 night dives made in this location during the year 2011. Preserved with formaldehyde solution 4% buffered (pH 6.9), and deposited in the collection of the Museum of Natural Sciences in Santa Cruz de Tenerife with reference TFMCBM/11310; MO/05140. María B. Caro and M.J. Sealey leg.

Diagnostic characters: Animals small to moderate size, up to 90 mm mantle length; total length to about 400 mm. Small mantle in relation to total length, elongate or saccular. Funnel organ W-shaped, slender, posterior angles rounded. Very long arms, 85 to 90% of total length, slender, often conspicuously asymmetrical (each arm may be much longer than the opposite arm of same pair). Enlarged suckers absent in both sexes. Right arm III of male hectocotylized, shorter than the opposite, bears 60 to 100 suckers. Short ligula: 1.9 to 2.5% of the hectocotylized arm length. Gills with 11 lamellae per outer demibranch. Transient papillae except over eyes. Coloured in life brown-yellow, grey brown or red-brown with dark transverse arm bars and heart-shaped pattern on dorsal mantle, often with green-iridescence, especially around eyes.

Habitat and biology: A benthic species taken on sandy and muddy bottoms. Usually it occurs from the littoral waters (about 6 m) to 200 m depth, but occasionally has been reported down to 350 m. Females lay over 10 000 eggs that may be brooded in the arms. Mature egg-size ranges between 0.9 and 1.6 mm. Larvae and

(Right page) Figure 1. *Amphioctopus burryi*, from off Radazul (Tenerife), sandy bottom at -17m. A: live specimen (1: detail of the small round papillae; 2: tiny papillae over each eye-ball; 3: dark-blue to purplish brown bands along dorsolateral surface of each arm; B: same specimen, preserved.
(Página derecha) Figura 1. Amphioctopus burryi, *de Radazul (Tenerife), fondo arenoso en -17m. A: ejemplar vivo (1: detalle de las pequeñas papilas redondas; 2: diminutas papilas encima de cada globo ocular; 3: bandas azul oscuro hasta castaño violáceo a lo largo de la superficie dorsolateral de cada brazo; B: el mismo ejemplar, preservado.*


1
2
3
A

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 cm
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 cm
B

Figure 2. *Macrotritopus defilippi*, from Tabaiba (Tenerife), sandy bottom at -15m. A: live specimen; B: the other specimen from the same locality, preserved.
Figure 2. Macrotritopus defilippi, *de Tabaiba (Tenerife), fondo arenoso en -15m. A: ejemplar vivo; B: el otro ejemplar de la misma localidad, preservado.*

juveniles are pelagic, and are characterized by extremely long ventrolateral arms. The characteristic long arms of the planktonic young seem to function in flotation, feeding, crawling and defense. No directed fisheries (Hanlon, Forsythe and Boletzky, 1985; Guerra 1992).

Distribution: Throughout the Mediterranean Sea, Eastern Atlantic from South Portugal to South Africa, Cape Verde Islands (Nesis, 1987; Guerra, 1992; Guerra *et al.*, 2013). Western Atlantic from the Bahamas to Brazil, in the Gulf of Mexico and the Caribbean Sea (Vecchione, 2002).

Remarks

The genus *Macrotritopus* needs revision. At present the only entirely described species is the one living in the Mediterranean and the eastern Atlantic, but the unresolved species of the western Atlantic are treated under the same name. The very characteristic "*Macrotritopus* larvae" have been found off South Africa and in the Indo-West Pacific, suggesting that several species may be comprised within this genus (GUERRA *ET AL.* in press).

Biogeography

The biogeographic model underlying ROSEN's (1975) EP/EA distributional tracks predicts that eastern Atlantic species ought to be basal owing to the vicariant separation of the New World and eastern Atlantic faunas by the Cenozoic opening of the South Atlantic Ocean (ca. 65–95 mya; PITTMAN, CANDE, LABRECQUE AND PINDELL 1993). This would suggest that the eastern populations of *A. burryi* and *M. defilippi* would be basal, suggesting support for Rosen's EP/EA model. However, there are many findings in marine organisms (LESSIOS, KESSING, ROBERTSON AND PAULAY 1999; MUSS, ROBERTSON, STEPIEN, WIRTZ AND BOWEN 2001; BANFORD, BERMINGHAM AND COLLETTE 2004) that do not fully support Rosen's hypothesis. These findings indicate a very recent separation of trans-Atlantic species and include the possibility of dispersal playing a central role (SCHELTEMA, 1973, 1995).

Considering that *A. burryi* and *M. defilippi* have small and intermediate sized eggs, respectively and that they produce planktonic young (HOCHBERG, NIXON AND TOLL 1992), dispersion at this stage of their life cycle could be the best explanation to their present biogeography. The new hatchlings and juveniles passively transported to the south-east by the Canary Current, which is a broad region of moderate flow where the temperate waters of the Azores Current are converted into the subtropical water that feeds into the North Equatorial Current that transport water towards the East (TOMCZAK AND GODFREY, 2003). This displacement would explain the presence of these two octopods species on both sides of the Atlantic Ocean and in the Canary Islands. Nevertheless, phylogenetic analyses using New World and eastern Atlantic specimens of *A. burryi* and *M. defilippi* should be needed for assessing genetic diversification.

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Succinea (*Calcisuccinea*) sp., an American land-snail newly established in Portugal and Spain (Gastropoda: Succineidae)

Succinea (*Calcisuccinea*) sp., un caracol terrestre americano nuevo para Portugal y España (Gastropoda: Succineidae)

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ABSTRACT

During 2010-2013 populations of an unfamiliar species of Succineidae were found to be established in southern Spain (near Málaga), north-eastern Spain (provinces of Barcelona and Tarragona) and west-central Portugal (Leiria and Porto de Mós). The shells, mantle coloration and genital anatomy are described. It is demonstrated that they do not resemble any European species of the family. However, characters of the distal genital anatomy match those of *Succinea* subgenus *Calcisuccinea* Pilsbry, 1948, which is native in North and Central America. Nevertheless, there are clear differences from the taxa known anatomically which are currently placed in this subgenus, so it is suggested that the Iberian specimens may be referable to one of the American taxa of Succineidae for which the anatomy is currently unknown and the species level taxonomy unresolved. The anthropogenically disturbed habitats at the Portuguese and some Spanish sites were drier than those occupied by any of the native Succineidae of western Europe. It remains to be seen whether this taxon will become a pest in Europe, where it is probably now too widespread to be eradicated.

RESUMEN

Durante 2010-2013, se descubrió que distintas poblaciones de una especie desconocida de Succineidae se habían establecido en hábitats alterados del sur y noreste de España (provincias de Málaga, Barcelona y Tarragona respectivamente) y el centro-oeste de Portugal (Leiria y Porto de Mós). Las conchas, coloración del manto y anatomía genital son descritas y se ha llegado a la conclusión de que estas no se corresponden con ninguna de las especies europeas de la familia. Los caracteres, principalmente de la anatomía distal genital, se acercan mucho a *Succinea* subgénero *Calcisuccinea* Pilsbry, 1948, que es nativa de América del Norte. No obstante, hay diferencias claras con los táxones que actualmente están encuadrados dentro de este subgénero. Se sugiere así, que los especimenes ibéricos podrían tratarse de uno de los numerosos táxones americanos de Succineidae cuya anatomía es desconocida en la actualidad y su taxonomía a nivel de especie está aún por resolverse. Los hábitats antropogénicamente alterados de las localidades ibéricas eran mucho más secas que las que ocupa cualquier Succineidae nativo de Europa occidental. Queda por ver si este taxon llegará a ser una plaga en Europa, donde es probable que en este momento esté ya demasiado extendida para ser erradicada.

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INTRODUCTION

During 2010-2013 populations of an unfamiliar species of Succineidae were found to be established in gardens and other disturbed habitats in southern Spain (near Málaga), in north-eastern Spain (provinces of Barcelona and Tarragona) and in west-central Portugal (Leiria and Porto de Mós). Compared to the European species of the family it has a relatively broad oval shell and dark markings on the mantle, producing an overall impression suggesting *Radix* (Lymnaeidae).

Identification of European Succineidae from shells alone is notoriously difficult and unreliable, because shells show few characters and these are often not diagnostic even of the genus (e.g. Kerney & Cameron, 1979: 59-61). Instead, taxonomy and accurate identification rely mainly on characters of the distal genitalia (Quick, 1933; Hecker, 1965; Patterson, 1971; Gittenberger, Backhuys & Ripken, 1984; Schileyko, 2007), so these formed the main basis for (sub-) generic identification in the present study. This paper therefore provides a key to European species of Succineidae based on the genital anatomy, showing that the unfamiliar Iberian taxon differs clearly from any native European species. Details are given of its genital anatomy, shells, mantle coloration, Iberian localities and habitats.

The distal genital anatomy of the Iberian specimens resembles that of *Succinea* subgenus *Calcisuccinea* Pilsbry, 1948, which is native in North America. Accurate identification to species level is apparently impossible because of the lack of information on genital anatomy of many American Succineidae, leading to poor taxonomic understanding. Unfortunately their shells often show insufficient characters for accurate species identification (e.g. Patterson, 1971; Pérez & López, 2003: 420-421).

MATERIAL AND METHODS

Numerous shells were studied from eight localities listed in the next section, six in Spain and two in Portugal. Living snails from both Portuguese sites were drowned in water overnight, then preserved in 80% Industrial Methylated Spirit. Dissections were carried out using a Meiji RZ Series stereo-microscope, drawings were made using a Meiji drawing tube and shell measurements were made with an eye-piece graticule. Proximal and distal refer to the position in relation to the ovotestis. "External" characters of the penial complex refer to those seen in dissected snails without opening the penial sheath.

Abbreviations: AH: height of shell aperture; B: shell breadth; CGAH: Collection of G.A. and D.T. Holyoak; CJSTA: Collection of J.S. Torres Alba; CRMCM: Collection of R.M. da Costa Mendes, CSQS: Collection of Sergio Quiñonero Salgado; DTH: D.T. Holyoak, GAH: G.A. Holyoak, H: shell height, IM: Inês Mendes, JSTA: J.S. Torres Alba, MM: Maricris Mendes, MNCN: Museum Nacional de Ciencias Naturales, Madrid, RMCM: R.M. da Costa Mendes, RRJ: Ramon Ruiz Jarillo, SQS: Sergio Quiñonero Salgado. The map references for localities are given as latitude and longitude (obtained from Flash Earth) or based on the U.T.M. grid. The Portuguese material described is in CGAH, CRMCM and MNCN, the Spanish material mainly in CJSTA and CSQS.

OBSERVATIONS AND DISCUSSION

Key to European species of Succineidae Beck, 1837

The following key to all the European taxa of the family also includes the *Succinea* (*Calcisuccinea*) sp. from Iberian localities which is discussed in more detail in later sections of this paper. Fig. 1 shows the characters of the penial complex and vagina used in the key. Note that the the narrow proximal part of the penis complex is described as an "epiphallus" in *Succinea* and *Succinella* e.g. by Gittenberger, Backhuys & Ripken (1984) and in this paper, but as part of the penis by Schileyko (2007).

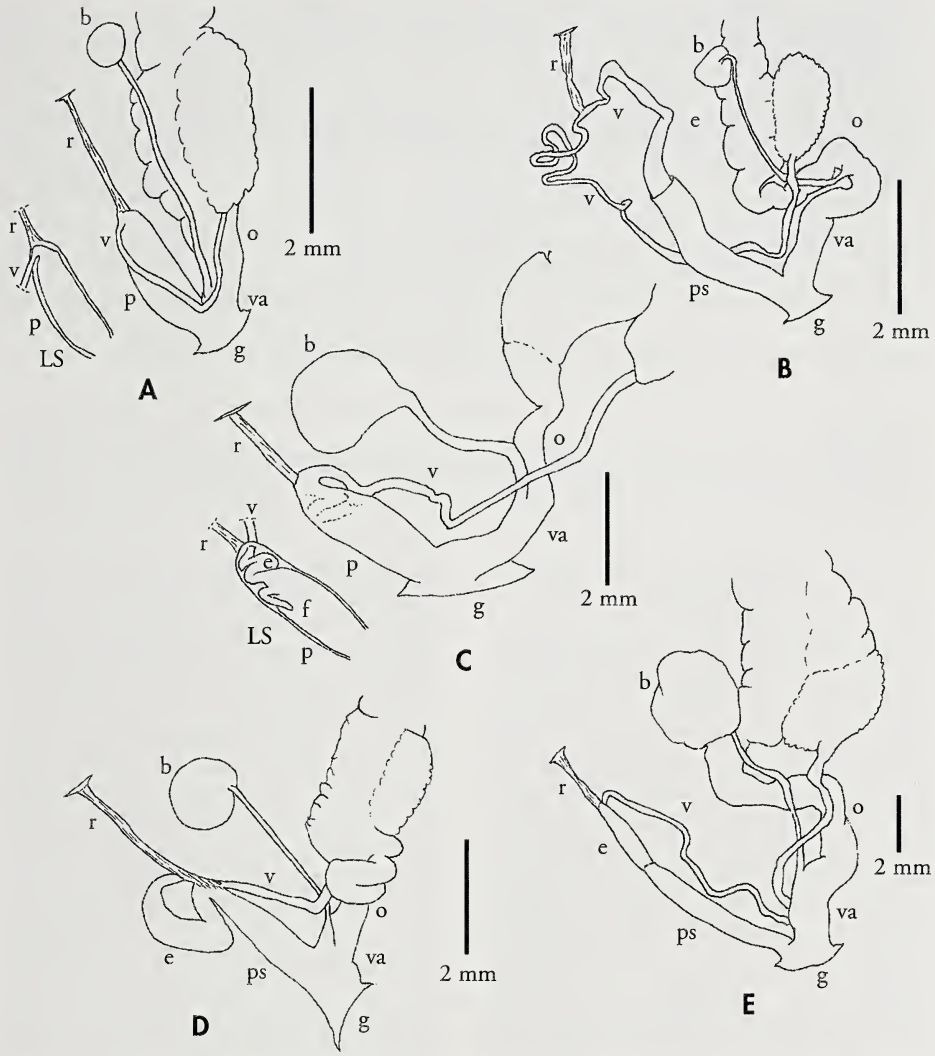

Figure 1. Penial complex and distal female genitalia in native European Succineidae and *Succinea* (*Calcisuccinea*) sp. A: *Quickella arenaria*, B: *Succinella oblonga*, C: *Oxyloma elegans*, D: *Succinea* (*Calcisuccinea*) sp. from Iberia, E: *Succinea* (*Succinea*) *putris*. A-C and E are redrawn with minor changes from SCHILEYKO (2007) after checking of all the species from the authors' dissections, which were also used to provide approximate scale bars; D is based on our Figure 4A. Abbrevations, b: bursa copulatrix; e: "epiphallus"; f: "flagellum"; g: opening of genital orifice; LS: longitudinal section of penis; o: free oviduct; p: penis; ps: penis sheath; r: penis retractor muscle; v: vas deferens; va: vagina.

Figura 1. Complejo penial y genitalia femenina distal en Succineidae nativos de Europa y Succinea (Calcisuccinea) *sp. A:* Quickella arenaria, *B:* Succinella oblonga, *C:* Oxyloma elegans, *D:* Succinea (Calcisuccinea) *sp. de la Península Ibérica, E:* Succinea (Succinea) putris. *A-C y E están redibujadas con pequeños cambios de* SCHILEYKO *(2007), después de comprobar todas las especies en las disecciones de los autores, las cuales se usaron también para añadir las escalas; D está basada en nuestra Figura 4A. Abreviaturas, b: bolsa copulatriz, e: "epifalo"; f: "flagelo"; g: abertura del orificio genital; LS: sección longitudinal del pene; o: oviducto libre, p: pene; ps: vaina del pene; r: músculo retractor del pene; v: vaso deferente; va: vagina.*

1 - Penial complex not divided into distinct parts externally 2
- Exterior of penial complex with wide distal part clearly demarcated from narrower proximal part 3

2 - Penis entirely covered by sheath, inside which convoluted epiphallus present at proximal end and blind appendix ("flagellum") on junction between penis and epiphallus (Fig. 1C) . . . . . .*Oxyloma* (3 spp.)
- Penis lacking sheath, epiphallus or "flagellum" (Fig. 1A) . . . . . *Quickella arenaria*

3 - Proximal part of penis ("epiphallus") forming an almost closed loop, due to attachment of retractor muscle to proximal end of epiphallus, distal end of vas deferens and proximal end of penis sheath; vagina so short that it is indistinct, or absent (Fig. 1D) . . . . . *Succinea* (*Calcisuccinea*) sp. from Iberia
- Proximal part of penis not forming an almost closed loop; vagina distinct 4

4 - Penis retractor muscle attached to distal part of vas deferens; vagina relatively long (Fig. 1B) . . . . . *Succinella oblonga*
- Penis retractor muscle attached to proximal end of penis ("epiphallus") or proximal end of penis sheath; vagina short (Fig. 1E) . . . . . *Succinea* (*Succinea*) *putris*

Native Succineidae of the Iberian Peninsula and NW. Africa

All of the western European species of Succineidae have been reported from the Iberian Peninsula, although occurrence of some of them has not been confirmed anatomically. Only *Oxyloma elegans* (Risso, 1826) is widespread and common, with numerous records confirmed by dissection. *Quickella arenaria* (Potiez & Michaud, 1835) has recently been confirmed anatomically from a few montane sites in Prov. Asturias (Holyoak & Holyoak, 2009) and Prov. Castellón (Martínez-Ortí & Pérez Ferrer, 2012). Records of the other species appear to have been based only on shells: *Succinea putris* (Linnaeus, 1758) is reported from NE. Spain (Haas, 1991: 355; Bech, 1990: 81) and Andorra (Martínez-Ortí, Borredà & Nicolau, 2010); *Succinella oblonga* (Draparnaud, 1801) has a few reports from NE. Spain (Haas, 1991: 356; Bech, 1990: 82) and an old and unconfirmed report from N. Portugal (Nobre, 1941); *Oxyloma sarsii* (Esmark, 1886) has reports from NE. Spain (as *S. elegans* in Haas, 1991: 353; Bech, 1990: 82) along with an isolated modern record from Prov. Madrid at a garden centre where it was presumed to be an accidental introduction (Soler, Moreno, Araujo & Ramos, 2006: 230). The only records from NW Africa that have been confirmed anatomically are of *Oxyloma elegans* and *Quickella arenaria* (Seddon & Holyoak, 1993).

There can be little doubt that the taxon we discuss in the following section is a recent arrival in the Iberian Peninsula, or at least one that has only become noticeably common and widespread in recent years. Its relatively wide shells immediately attract attention as different to those of any of the native Succineidae of western Europe. The prevalence of records in anthropogenically disturbed habitats may also point to an introduced rather than native species.

Succinea Draparnaud, 1801

Subgenus *Calcisuccinea* Pilsbry, 1948 (Pilsbry, 1948: 826, *pro sect.*; type species *Succinea campestris* Say, 1817 by original designation)

Localities and other data on specimens. Portugal, Prov. Beira Litoral [Leiria district]: Leiria, on exterior of north wall of Escola Secundária de Domingos

Table I. Measurements (mm) of shells of *Succinea* (subgenus *Calcisuccinea*) sp. from Spain and Portugal.
Tabla I. Medidas (mm) de conchas de Succinea *(subgénero* Calcisuccinea*) sp. de España y Portugal.*

Locality	Sample no.		H	B	AH	B/H
Prov. Málaga: Mijas	10636	largest shell	13.3	8.7	9.0	0.65
Prov. Málaga: Benalmádena	11494	largest shell	9.9	6.6	6.3	0.67
Prov. Tarragona: El Vendrell	SQS leg.	largest shell	10.0	6.6	6.3	0.66
Estremadura: Porto de Mós	P207	largest shell	9.6	6.2	7.0	0.65
Beira Litoral: Leiria	P208	largest shell	13.6	8.3	9.8	0.61
	P208	next largest	11.0	7.4	8.0	0.67

Sequeira, Rua dos Mártires do Tarrafal, near the foot of the slope below the western side of the Castelo de Leiria (*ca* 39°44′48.2″N., 8°48′46.6″W.; 29SND19), leg. IM and RMCM, 24 Sept. 2011, 7 shells (collected alive) CRMCM; by Escola Secundária de Domingos Sequeira on Rua Mártires do Tarrafal, Leiria (29SND161/996), 94 m alt., and nearby on exterior of wall surrounding this school, leg. DTH, GAH, IM, MM and RMCM, 9 Oct. 2011, many shells and material in alcohol in CGAH (site P208), 1 shell CRMCM; 14 Apr. 2012, 61 specimens in alcohol, leg. RMCM, to be lodged at MNCN. Prov. Estremadura [Leiria district]: Porto de Mós, Parque Verde (*ca* 39°35′54.8″N., 8°49′14.0″W.; 29SND18), on wall surfaced with marble beside an artificial pool, leg. MM and RMCM, 24 Sept. 2011, 4 shells (collected alive) CRMCM; Parque Verde, at Porto de Mós (29SND15400/83182), 139 m alt., leg. GAH, DTH and RMCM, 9 Oct. 2011, shells and material in alcohol CGAH (site P207), 4 shells (collected alive) CRMCM.

Spain, Prov. Barcelona: Cubelles (31TCF86), in greenhouse, leg. SQS & RRJ, Aug. 2012, shells only, CSQS. Prov. Málaga: Benalmádena (30SUF6249), leg. Juan Antonio Salamanca, 65 shells in CJSTA (no. 11494); Cala de Mijas, Mijas (30SUF5041), leg. José Antonio Aranda, 5 shells in CJSTA (no. 10636); El Chaparral, Mijas (30SUF5242), living specimen observed and photographed by Katrina Roberts, 12 Mar. 2011. Prov. Tarragona: El Vendrell (31TCF76), detritus in very humid site, 30 m alt., leg. SQS, Aug. 2011, material in alcohol, CGAH & CSQS; Altafulla, around River Gaià (31TCF65), 8 m alt., leg. SQS & RRJ, 11 Feb. 2013, shells only, CSQS.

Description and identification to subgenus. Representative shells are illustrated in Fig. 2. They resemble shells of European Succineidae in having few whorls (up to 3.5) and being thin, more or less translucent, with weak and rather irregular sculpture consisting mainly of growth lines. Fresh shells vary in colour from light yellowish or buff to pinkish tinged, but not as bright as the amber colour often present in European *Oxyloma* spp. The aperture is relatively large and the spire short, as in European *Succinea putris* (Linnaeus) and *Oxyloma*, but the overall shell shape is broader in proportion to its height (B/H 0.61-0.67 in the largest shells) in comparison to normal individuals of the European species. Measurements of the largest shells in each of our samples are given in Table I.

The snails at the two Portuguese localities and El Vendrell (Prov. Tarragona) mainly showed striking patterns of dark or dark and light coloration on external surfaces of the mantle. Many of the shells are translucent, so that the dark pattern on the body inside results in an appearance recalling that of *Radix* spp. (Lymnaeidae). This differs markedly from the appearance of all native Succineidae of western Europe, which

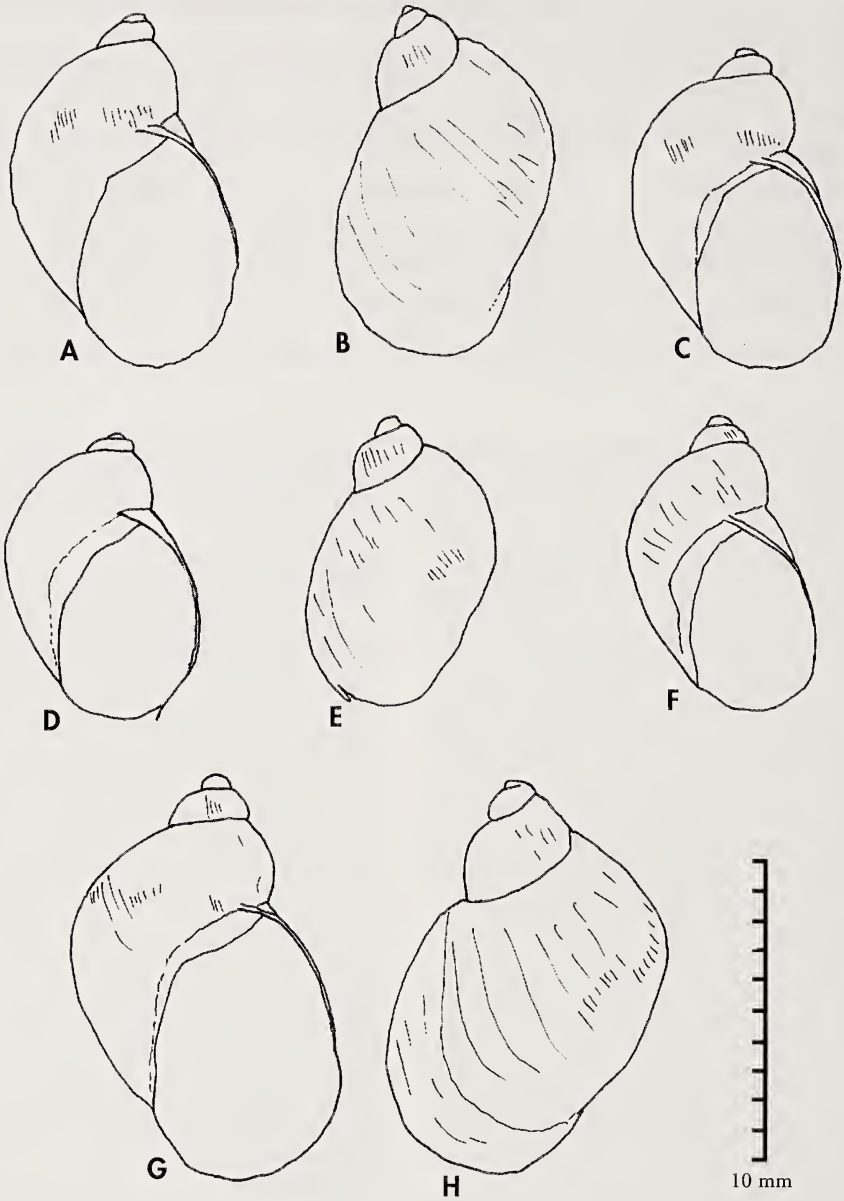

Figure 2. Shells of *Succinea* (*Calcisuccinea*) sp. A-C: Portugal, Prov. Beira Litoral, Leiria (CGAH site P208), A and B show apertural and abapertural views of same shell; D, E: Portugal, Prov. Estremadura: Porto de Mós (CGAH site P207), apertural and abapertural views of same shell; F: Spain, Prov. Málaga: Benalmádena (CJSTA no. 11494); G, H: Spain, Prov. Málaga: Cala de Mijas, Mijas (CJSTA no. 10636), apertural and abapertural views of same shell.

Figura 2. Conchas de Succinea (Calcisuccinea) sp. *A-C: Portugal, Prov. Beira Litoral, Leiria (CGAH localidad P208), A y B muestran vistas frontal y dorsal de la misma concha; D, E: Portugal, Prov. Estremadura: Porto de Mós (CGAH localidad P207), vistas frontal y dorsal de la misma concha; F: España, Prov. Málaga: Benalmádena (CJSTA nº 11494); G, H: España, Prov. Málaga: Cala de Mijas, Mijas (CJSTA nº 10636), vistas frontal y dorsal de la misma concha.*

Figure 3. Drawings of colour patterns on bodies of *Succinea* (*Calcisuccinea*) sp. preserved in spirit from Portugal, Prov. Beira Litoral, Leiria (CGAH site P208). A/D, B/E and C/F show right and left sides of the body of three snails with light, medium and heavy pigmentation respectively.
Figura 3. Dibujos de los patrones de color en el animal de Succinea (Calcisuccinea) sp. *conservados en alcohol de Portugal, Prov. Beira Litoral, Leiria (CGAH localidad P208). A/D, B/E y C/F muestran los lados derecho e izquierdo respectivamente de tres caracoles con pigmentación clara, media y fuerte.*

have plain mantle coloration, varying from cream to grey or dark grey (due to tiny dots of black pigmentation), without any conspicuous darker or paler markings. As shown in Fig. 3, the dark patterns on our *Succinea* (*Calcisuccinea*) varied widely between individuals at the same site. The least pigmented snails had almost no markings on their whitish, pale cream or pale grey mantles; others had a few blackish lines and scattered blackish and grey spots and blotches (Figs. 3 A/D). More heavily marked individuals had whitish blotches and spots and black blotches, lines and spots, the black marks often forming a reticulate pattern (Figs. 3 B/E). Dark individuals had large areas of black and grey on the mantle, the black often forming bold irregular lines and contrasting sharply with adjacent whitish markings (Figs. 3 C/F). It seems likely that the markings on the mantle tend to conceal resting snails on natural substrata, but they are ineffective for this on smooth marble and white-painted masonry of walls. Parts of the body that extend outside the shell lack striking markings, the foot being consistently pale, whereas dorsal areas of the exposed body vary from pale to dark grey, often darkest on the top of the head and tail.

The genital anatomy has been studied in six specimens from Portugal (all ± mature) and two from El Vendrell in Prov. Tarragona (one immature, one nearly mature). It was similar in mature individuals from both the Leiria and Porto de Mós localities (Fig. 4) and the nearly mature specimen from Prov. Tarragona. Characters of genus *Succinea sensu lato* were present as follows: right ommatophore passing through angle between penis and oviduct; penis a simple tube, provided with a sheath and passing proximally into an epiphallus, lacking any appendix at proximal end; vas deferens slender. Characters of subgenus *Calcisuccinea* (as described by PILSBRY, 1948: 826 and SCHILEYKO, 2007: 2084) present were as follows: penis slender with ample sheath, from which the epiphallus emerges; the junction of the vas deferens with the epiphallus enveloped in the distal part of the penial retractor muscle, which is also attached to the proximal end of the penis sheath, so that the epiphallus is held in an almost closed loop; duct of bursa copulatrix slender almost throughout its length; free oviduct not coiled around proximal part of duct of bursa copulatrix; vagina very short or absent.

Subgenus *Novisuccinea* Pilsbry, 1948 is similar in having the epiphallus forming a loop free from the penis sheath with the distal end of the penial retractor muscle attached to the proximal end of the penis sheath. Furthermore, its type species *Succinea ovalis* Say, 1817 also has very similar shell shape and dark mantle pigmentation to our Iberian material (PILSBRY, 1948: 800-806). Nevertheless, *S. ovalis* and other taxa in subgenus *Novisuccinea* show clear anatomical differences from our Iberian specimens in having a long vagina and the duct of the bursa copulatrix very wide at its distal end and tapering gradually to the proximal end, with the coiled oviduct wrapped around the proximal part (PILSBRY, 1948; FRANZEN, 1959; HOAGLAND AND DAVIS, 1987).

Difficulties in species identification. PILSBRY (1948) referred only three taxa comprising two species without doubt to his Section *Calcisuccinea*, which he regarded as "a subdivision of *Novisuccinea*": *S. campestris* Say, 1817 (type-species of the Section and now of the subgenus; ranging from North Carolina to Florida), *S. luteola* Gould, 1848 (ranging from Louisiana to Arizona and widespread in Mexico) and *S. luteola floridana* Pilsbry, 1905, possibly a distinct species (from Florida and Alabama). More detailed anatomical studies by FRANZEN (1971) later confirmed that *S. vaginacontorta* Lee, 1951 from Kansas is also a *Calcisuccinea*, bringing the total number of species confirmed for the subgenus to three, or four if *floridana* is distinct from *S. luteola*. SCHILEYKO (2007: 2085) gave the distribution as N. America with "8 spp.", but the basis for this total is unclear unless it includes taxa with differing anatomy (*S. concordialis* Gould, 1848; *S. avara* Say, 1824) or undescribed anatomy (*S. gabbi* Tryon, 1866; *S. californica* Fischer and Crosse, 1878; *S. oregonensis* Lea, 1841).

The three well understood North American species of *Succinea* (*Calcisuccinea*) appear to differ from the Iberian specimens in features of the genital anatomy and most also differ in shell characters (cf. PILSBRY, 1948; FRANZEN, 1971). *S. campestris* has a similarly wide, globose shell, but the penis is shorter and wider, the wall of the penis sheath much thicker, and the loop of the epiphallus is much smaller relative to the penis length (less than one-third: PILSBRY, 1948: 829; SCHILEYKO, 2007: 2085). *S. luteola* and *S. luteola floridana* have a somewhat longer penis and thinner-walled penis sheath, but this and the other North American species again differ in having the epiphallus loop shorter in proportion to penis length. With the possible exception of a few *S. l. floridana*, they also differ in having relatively much taller shells with more whorls in the spire. Furthermore, none of the *Calcisuccinea* species is reported as showing a distinctive dark colour pattern on the mantle except for *S. concordialis* which has markedly different penial anatomy, so that its subgeneric allocation is questionable (PILSBRY, 1948: 826, 829, 835).

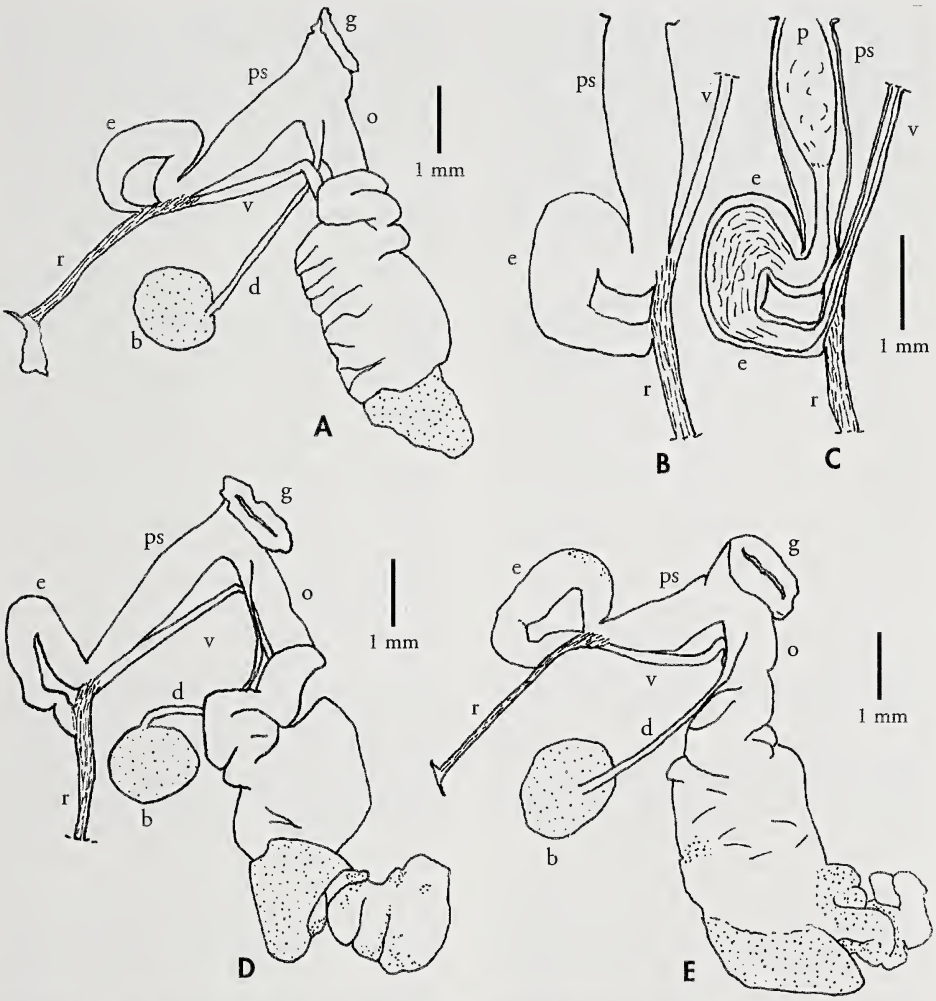

Figure 4. Genital anatomy of *Succinea (Calcisuccinea)* sp. from Portugal. A-C and D: two individuals from Prov. Beira Litoral, Leiria (CGAH site P208); E: from Prov. Estremadura: Porto de Mós (CGAH site P207); B and C show details of the penial complex in the same specimen as drawing A, at a larger scale, from the exterior in B, in cross-section in C; b: bursa copulatrix; d: duct of bursa copulatrix; e: epiphallus; g: opening of genital orifice; o: free oviduct; p: penis; ps: penis sheath; r: penis retractor muscle; v: vas deferens.

Figura 4. Anatomía genital de Succinea (Calcisuccinea) *sp. de Portugal. A-C y D: dos individuos de Prov. Beira Litoral, Leiria (CGAH localidad P208); E: de Prov. Estremadura: Porto de Mós (CGAH localidad P207); B y C muestran detalles del complejo penial en el mismo espécimen. A, a mayor escala, desde el exterior en B, en sección cruzada en C; b: bolsa copulatriz; d: conducto de la bolsa copulatriz; e: epifalo; g: abertura del orificio genital; o: oviducto libre; p: pene; ps: vaina del pene; r: músculo retractor del pene; v: vaso deferente.*

The genital anatomy thus apparently remains undescribed for several N. American *Succinea* (see above) that might belong in subgenus *Calcisuccinea*. Indeed, the comments by PATTERSON (1971: 183) still remain true, that: "There

are a great many succineid species in North America and especially in the southern United States. Most of these species have not been critically examined with regard to reproductive anatomy (especially the forms from the western United States), and until this is done it is premature to classify the North American *Succinea* species into sections or subgenera."

The same applies to numerous other nominal taxa named as *Succinea* species from the West Indies (e.g. *S. dominicensis* L. Pfeiffer, 1851, from Haiti) and Central America (e.g. *Succinea recisa* Morelet, 1851 named from a type locality in eastern Guatemala, *S. costaricana* von Martens, 1898 named from Costa Rica). *S. recisa* was reported from as far south as Panama by VON MARTENS (1890-1901: 339), who described it as distinct from the other Central American Succineidae species in its very short spire. Nevertheless, PÉREZ & LÓPEZ (2003: 420-421) noted that *S. recisa* in western Nicaragua may approach *S. costaricana* in shell form although they are "perfectamente diferenciables desde el punto de vista anatómico", but they did not describe or figure the anatomy of either species.

The Iberian populations resemble *S. costaricana* in having a broadly ovate shell, of similar size at 8-13.5 mm high, with spire and aperture similar in shape to those of that species (VON MARTENS, 1890-1901: 338, pl. 19 figs 6; VILLALOBOS AND MONGE-NÁJERA, 2004; cf. our Table I), and also in having dark markings on the mantle (VILLALOBOS,· MONGE-NÁJERA, BARRIENTOS AND FRANCO, 1995). The latter authors also reported this "tropical agricultural pest" species as living at high density (282,900 individuals/ha) away from water, on an ornamental plant farm in Costa Rica which grew mainly *Dracaena* spp. Although F.G. Thompson is thanked for corroborating their species identification, it nevertheless seems uncertain that *S. costaricana* is the correct name for the species involved. Other Central American *Succinea* with older names have shells of generally similar form, notably *S. undulata* Say, 1829, *S. guatemalensis* Morelet, 1849, *S. virgata* von Martens, 1868 and *S. pueblensis* Fischer and Crosse, 1877. Secure identification of the Costa Rican snails would therefore need to exclude all these taxa with earlier names through detailed studies, including studies of the genital anatomy, which have not been reported in the literature.

The website of the GEORGIA INVASIVE SPECIES TASK FORCE ("2006") lists *Succinea dominicensis* and *Calcisuccinea dominicensis* (Pfeiffer), noting that "These Mollusks have recently been determined to be "actionable" snails. They have been known to arrive in the United States from Haiti and the Dominican Republic. Inspectors should watch for these snails when inspecting any agricultural items from these countries." [They] "can reproduce rapidly in a greenhouse or nursery, resulting in severe losses. They can also become established outdoors where temperatures and humidity are favorable. Their introduction is a significant threat to the US fruit and horticultural plant industries." Identification notes add that they "closely resemble another "actionable" snail, *Succinea costaricana* .... have a thicker shell than most other *Succinea* spp., they are usually light to pale brown in color, and tend to have a somewhat whitish cast to the shell. Their length is approximately 1 cm ... or smaller." It is unclear why this taxon is placed in *Calcisuccinea*, but unpublished anatomical studies perhaps lie behind it. The original description (PFEIFFER, 1851: 147) is of an oval, solid shell of 3½ whorls, 11.5 mm long, 7 mm wide, with aperture 7.5 mm long, from St. Domingo [Haiti] collected by Sallé. The description could apply to our Iberian shells, but also to various other species of Succineidae with broad shells. It is unclear that *S. dominicensis* is a valid species in the apparent absence of detailed published studies, particularly the lack of data on its genital anatomy. Admittedly most *Succinea* from the West Indies were described after 1851, but *S. sagra* d'Orbigny, 1842, is an older name, as are those of two of the Central American taxa listed above.

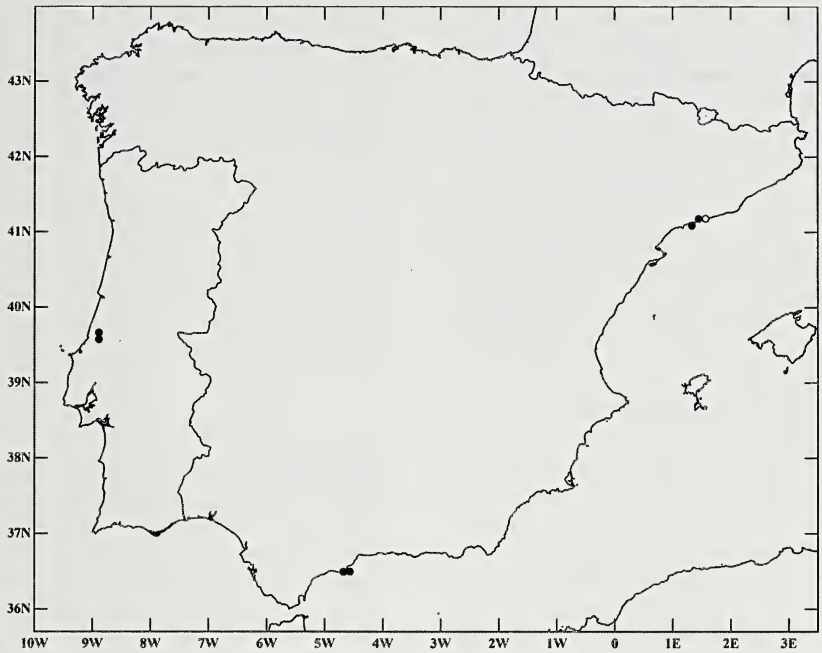

Figure 5. Localities at which *Succinea* (*Calcisuccinea*) sp. has been found in Spain and Portugal, plotted in ten-kilometre squares of the U.T.M. Grid. An open symbol represents a record from a greenhouse; closed symbols represent sites in the open air.

Figura 5. Localidades en las que Succinea (Calcisuccinea) sp. *ha sido hallada en España y Portugal, situadas en cuadrados de diez kilómetros dentro de la cuadrícula U.T.M. Un símbolo vacío representa un registro de invernadero; los símbolos sólidos representan localidades al aire libre.*

The specific identity of the Iberian material is thus an unsolved problem at present. It is likely to remain unclear until the taxonomy and especially the genital anatomy of Succineidae from Central America, the West Indies and the south-western U.S.A. is studied in more detail.

Habitats and behaviour. At the Leiria locality the snails were aestivating or resting singly on masonry (mostly painted white) of modern walls up to 2 m above ground level, along several hundred metres of the boundary around grounds of a school. The adjoining garden was sparsely planted with bushes and herbs and only a few trees were present. There was no standing water, ditch, or other aquatic habitat. At Porto de Mós it was found in a small area in an open, grassy, public park that had been created within the past few years. Some snails were resting or aestivating on vertical marble surfaces of walls, up to 2.5 m above the ground; others were resting in wet grasses at the base of this wall. This part of the site lacked any persistent standing water, although a shallow hollow at the foot of the wall may flood after rain and an artificial pond is not far away. A ditch containing a small diverted stream was present about 30 metres away, but the only succineid found there was *Oxyloma elegans*.

In Prov. Málaga, empty shells were found in a dry ravine between gardens of a residential area. The other two populations there were found in gardens, among dry litter. The only living specimen found was active after rain. In Prov. Barcelona shells were found in a green-

house; in Prov. Tarragona it was found living in detritus at a humid locality and as dead shells near a river.

The habitats at both the Portuguese and Prov. Málaga sites were therefore much drier than those normally occupied by any of the native west European Succineidae. These habitats were also greatly disturbed by man, at least four of the five sites having only planted vegetation in heavily managed situations. As noted above, a species of Succineidae is regarded as an agricultural pest in Costa Rica and several species of the family are at least potential pests in Georgia, U.S.A. It remains to be seen whether the taxon that has become established in Portugal and Spain will prove troublesome. Our records of its occurrence here at eight localities up to >800 km apart (Fig. 5) must hint at many more populations as yet unfound having become established, so that it is almost certainly too late to eradicate it.

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The genus *Haplocochlias* (Gastropoda, Skeneidae)

El género *Haplocochlias* (Gastropoda, Skeneidae)

Federico RUBIO*, Raúl FERNÁNDEZ-GARCÉS** and Emilio ROLÁN***

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RESUMEN

Se estudian las especies conocidas del género *Haplocochlias* Carpenter, 1864, actualmente incluidas en la familia Skeneidae. Se han estudiado un total de 29 taxones, de los cuales 17 eran previamente conocidos, 11 se describen como especies nuevas y una más se queda sin nombre específico. Cada una de las especies se ilustra mediante fotografías de microscopio electrónico de barrido, clarificando su identidad y discutiendo su variabilidad específica, cuando esto es posible. Se aportan nuevos datos sobre el hábitat, distribución y rango batimétrico de algunas de estas especies. *Fossarus (Gottoina) compacta* Dall, 1889, *Parviturbo calidimaris* Pilsbry & McGinty, 1945, *Liotia erici* Strong & Hertlein, 1939, *Homalopoma concepcionensis* Lowe, 1935, *Parviturbo francesae* Pilsbry & McGinty, 1945, *Cyclostrema turbinum* Dall, 1889 y *Fossarus (Gottoina) bella* Dall, 1889 son transferidos en el presente trabajo al género *Haplocochlias*. Se rechaza la supuesta sinonimia de *Haplocochlias onaneyi* con *Haplocochlias williami*. Se designa un lectotipo para la especie *Fossarus* (*Gottoina*) *compacta* Dall, 1889. En un apéndice se comentan las especies fósiles y otros taxones (*Gottoina* y *Lophocochlias*) relacionados o parecidos con el género en estudio, mostrando sus especies tipo.

ABSTRACT

The known species of the genus *Haplocochlias* Carpenter, 1864, currently included in the family Skeneidae, are studied. We have included a total of 29 species, of which 17 were previously known, 11 are described as new species, and one more is kept without a specific name. Each species is figured with scanning electron micrographs, and its variability discussed, when possible. New information on habitat, distribution, and bathymetric range of some species is provided. *Fossarus (Gottoina) compacta* Dall, 1889, *Parviturbo calidimaris* Pilsbry & McGinty, 1945, *Liotia erici* Strong & Hertlein, 1939, *Homalopoma concepcionensis* Lowe, 1935, *Parviturbo francesae* Pilsbry & McGinty, 1945, *Cyclostrema turbinum* Dall, 1889 and *Fossarus (Gottoina) bella* Dall, 1889 are here transferred to the genus *Haplocochlias*. The alleged synonymy of *Haplocochlias onaneyi* with *Haplocochlias williami* is rebutted. A lectotype is designated for *Fossarus (Gottoina) compacta* Dall, 1889. In an appendix, fossil species and other taxa (*Gottoina* and *Lophocochlias*) related to or resembling *Haplocochlias* are commented on, and their type species illustrated.

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INTRODUCTION

According to HICKMAN & MCLEAN (1990: 146), there are two shallow-water genera in the family Skeneidae which possess a thickened aperture: *Haplocochlias* Carpenter, 1864 and *Parviturbo* Pilsbry & McGinty, 1945, both distributed in the eastern Pacific and western and southern Atlantic. Both genera share anatomical and radular characters, which was why HICKMAN & MCLEAN (1990) united them as the *Parviturbo - Haplocochlias* group in the family Skeneidae.

The *Haplocochlias-Parviturbo* group of species are interstitial, usually sublittoral or infralittoral. Like European skeneid species of the genera *Skenea, Skeneoides, Dikoleps* or *Lodderena,* they tend to live in relatively shallow water in the interstices of the gravel on rocky beaches, in the interstices of coarse sediments under stones, in maërl, coralline sediments and in *Laminaria* beds on rocks. An element common to many of these habitats is the presence of calcareous algae.

From the species of *Haplocochlias,* those of *Parviturbo* can be differentiated because they have more prominent spiral cords in short number (usually 8 on the last whorl), sometimes some of them may be nodose and the columella is not widened at its base and not reflected towards the umbilicus.

The shells are so minute that it is virtually impossible to distinguish them in their natural environment. For this reason these species can only be collected through sampling of algae, coralline sand, gravel, and other sediments. In most samples only empty shells are found.

Since CARPENTER (1864) created the genus *Haplocochlias* with *H. cyclophoreus* as sole included species, a total of 8 species have been described: two (*H. lucasensis* and *H. cyclophoreus*) on the Eastern Pacific coast and seven (*H. swifti, H. ortizi, H. nunezi, H. cubensis, H. moolenbeeki, H. risoneideneryae* and *H. williami*) on the shores of the Western Atlantic. One more species, *Haplocochlias costaricensis* Robinson, 1991 is denoted by an unavailable name.

We have reviewed two species originally placed by DALL (1889) in the genus *Gottoina*: *Fossarus (Gottoina) bella* and *Fossarus (Gottoina) compacta,* comparing them with *Gottoina sulcifera* A. Adams, 1863, the type species of the genus, and reassigned them to *Haplocochlias*. Likewise, we have revised and figured *Haplocochlias (Lophocochlias) minutissimus* Pilsbry, 1921, originally described in *Haplocochlias,* and consider *Lophocochlias* Pilsbry, 1921 as full genus. We also have revised the species placed hitherto in the genus *Parviturbo* Pilsbry & McGinty, 1945 and in our opinion four of them (*Parviturbo concepcionensis, P. erici, P. calidimaris* and *P. francesae*) should be included in *Haplocochlias* due to their morphological affinity with other species of this genus.

The scarcity of works related with species of the genus *Haplocochlias,* the difficulties often encountered in their specific differentiation, the errors in the identification of previously named species due to lack of appropriate illustrations or their poor quality, has prompted us to carry out the present work. To do this, we have reviewed all known species, both Pacific and Atlantic, comparing the material studied with the type material and presenting as much information as possible for each species: habitat, bathymetry, geographical distribution and differential characteristics.

There are few fossil species, and although this is not the focus of this work, we present some information in Appendix 1. Some genera have been considered related to *Haplocochlias,* but, after the study of their type species, we concluded that they (*Gottoina* and *Lophocochlias*) are not related and we discuss them in Apendix 2.

MATERIAL AND METHODS

Most of the material studied in the present work was obtained from sediments collected by diving or from dredgings and later sorted under a stereoscopic microscope. Consequently most of the material is composed of empty shells from the shell grit; occasionally a shell with soft parts could be obtained. An important part of the material studied is from Cuba, and

this material was mainly obtained from collections by the second author at Cienfuegos Bay and later deposited mostly in the MHNS. For this reason, at the beginning of this study we only examined Cuban shells. Subsequently we included the material obtained by the third author on several trips to Yucatan, Mexico, Guatemala, Nicaragua, and south and west Cuba. Finally, we received material collected by Colin Redfern from the Bahamas, Marlo Krisberg, Emilio García and Jacques Pelorce and an important amount from the collection of Harry G. Lee, all of which considerably amplified the study in terms of biodiversity and zoogeography. We studied types and other material in other private collections and several museums.

The description of the protoconch whorls was made following the method of VERDUIN (1976) in which the whorls are counted based on a concept of the nucleus.

Abbreviations:

AMNH American Museum of Natural History, New York, USA
ANSP Academy of Natural Sciences, Philadelphia, USA
BMSM Bailey-Matthews Shell Museum, Sanibel, Florida
CITMA Ministerio de Ciencia y Tecnología y Medio Ambiente, Havana, Cuba
FLMNH Florida Museum Natural History, Gainesville, USA
FMNH Field Museum of Natural History, Chicago, USA
IES Instituto de Ecología y Sistemática, Havana, Cuba
LACM Los Angeles County Museum, USA
MCZ Museum of Comparative Zoology, Cambridge, Massachusetts, USA
MHN "Carlos de la Torre" de Holguín, Cuba
MHNS Museo de Historia Natural "Luis Iglesias", University of Santiago de Compostela (coll. E. Rolán), Spain
MNCN Museo Nacional de Ciencias Naturales, Madrid, Spain
MNH of Santa Cruz de Tenerife, Canarias
MNHN Muséum National d'Histoire Naturelle, Paris, France
MPH Museo Poey, Havana, Cuba
NHMUK Natural History Museum of the United Kingdom (formerly BM (NH), England
NMR Natural Museum of Rotterdam, The Netherlands
SDSNH San Diego Society of Natural History, USA
UFRPE Universidade Federal Rural, Pernambuco, Brazil
USNM National Museum of Natural History, Washington, USA
ZMA Zoological Museum, Amsterdam, (now Naturalis, Leiden), The Netherlands
CCR collection of Colin Redfern, Boca Raton, Florida, USA
CEG collection of Emilio Garcia, Louisiana, USA
CFG collection of Raúl Fernández-Garcés, Cienfuegos, Cuba
CFR collection of Federico Rubio, Valencia, Spain
CHL collection of Harry G. Lee, Florida, USA
CJP collection of Jacques Pelorce, Le Grau de Roi, France
SEM scanning electron microscopy/microscope/micrograph
sp specimen with soft parts
s empty shell
j juvenile
f fragment

SYSTEMATIC PART

Superfamily TURBINOIDEA Rafinesque, 1815
Family SKENEIDAE Clark, 1851

Genus *Haplocochlias* Carpenter, 1864

Haplocochlias Carpenter, 1864. *Annals and Magazine of Natural History*, (3)13: 476 [Type species by monotypy: *Haplocochlias cyclophoreus* Carpenter, 1864, Cape St. Lucas, Mexico; Recent species].

Original description: "*Testa* Colloniam *simulans, sed haud margaritacea: aperture circularis, varicose: columella haud callosa*".

KEEN (1971): "*Globose shells with fine spiral sculpture, narrow umbilicus and thickened outer lip*".

HICKMAN & MCLEAN (1990) provided a detailed description of the group consisting of the genera *Haplocochlias* and *Parviturbo*, based on the radula of both genera and the external anatomy of a preserved although contracted specimen of *Haplocochlias swifti*, which was dehydrated by the technique of critical-point and observed under SEM:

"*The shell is small to minute (2–5 mm in height), narrowly umbilicate, non-nacreous, white, with strong spiral sculpture, a circular generating curve, and a complete peristome that is terminally thickened. The operculum is completely corneous, multispiral with a short growing edge, and not enveloped exteriorly by the foot.*

The ctenidium is apparently monopectinate, with at last 30 elongate leaflets, and lacks a free tip and bursicles. Cephalic tentacles are relatively long, extending well forward of the snout tip. The cephalic tentacles are flattened dorsally, with micropapillae extending laterally. There are three pairs of long epipodial tentacles that also bear micropapillae.

"*The radulae of* Haplocochlias *and* Parviturbo *are of the same plan as lower turbinids, although the rachidian tooth is unusually broad, exceeding the combined width of all the adjacent lateral teeth. The laterals are well developed and are similar size and shape, with the characteristic bend in the shaft, and with long overhanging cusps with finely serrate outer margins and simple inner margins. The lower shafts and bases are relatively thin and produced into strongly overlapping flanges. This is the only skeneiform group that has a distinct lateromarginal plate, a well-developed structure that is fused to the first marginal tooth shaft and cusp. In addition to the within-interactions of the lateromarginal plates with the outer laterals and the between-row interactions of the plates with one another, there is a particularly complex interaction with the inner marginal teeth. The base of the plate extends behind and in front of the lower portion of the shafts of the inner marginals, providing the potential for transmitting forces and promoting alignment during both protraction and retraction of the radula. The inner marginal teeth are not enlarged, and the marginals are all of the same form with long, narrow, strongly overhanging cusps and a well-developed food-collecting groove*".

"*Many more data are needed before the relationships of the skeneiform taxa can be analyzed. Data on the condition of the ctenidium are of special importance. The ctenidium has been examined in only one genus in addition to* Haplocochlias *(McLean, personal observation). Preserved material of* Dillwynella *provided by Marshall, has revealed a gill that is similar to that of* Haplocochlias *and extends this set of three characters (monopectinate condition, loss of bursicles, and lack of free tip) beyond the shallow-water eastern Pacific and western Atlantic clade*".

"*Other characters that may be of significance in evaluating monophyly are the shape of the anterior end of the foot, the length and shape of the cephalic and epipodial tentacles, and arrangement and prominence of macropapillae on the cephalic and epipodial tentacles. For example, the "narrow auricles" described on the foot of* Parviturbo *by* PILSBRY & MCGINTY *(1945) need to be compared in live or carefully relaxed and preserved material with the "lateral points" that* FRETTER & GRAHAM *(1977) have described as elongated into "tentaculiform outgrowths", and these in turn must be compared with the epipodial outgrowths of different types that occur in a variety of Trochacean clades.*"

A short condensed description of the genus would be: The shell is small to minute (1-6 mm in height), turbiniform, with a closed to narrowly opening umbilicus with spiral cordlets inside. Protoconch ¾ whorl, smooth or with spiral cordlets. Teleoconch with a rounded or slightly angulous periphery; ornamentation formed by numerous spiral cords and axial striae with micro tubercles on their interspaces. Aperture prosocline, peristoma continuous; columella sometimes reflected towards the

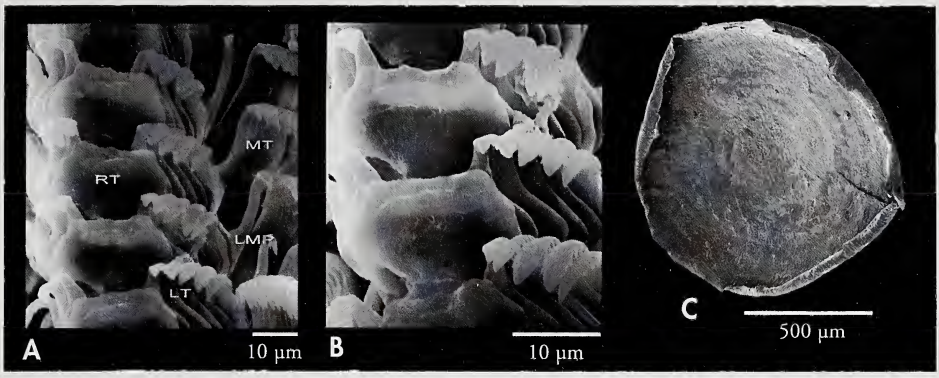

Figure 1. *Haplocochlias arrondoi* spec. nov. A, B: radula. Faro de los Colorados, Cienfuegos, Cuba; C: operculum.
Figura 1. Haplocochlias arrondoi *spec. nov. A, B: rádula. Faro de los Colorados, Cienfuegos, Cuba; C: opérculo.*

umbilicus, widened at its base with the presence in some species of a depressed area in the crossing point with the umbilical cord. Outer lip wide or fine, crenulated or expanded frontally.

CARPENTER (1864) mentions about *Haplocochlias*: "*Its affinities may be with* Ethalia *H. & A. Adams, 1854.*" The genus was placed in the Cyclostrematidae by FISCHER (1885) and subsequently in the family Skeneidae by KNIGHT *ET AL.* in MOORE (1960). The genus *Gelasinostoma* Gardner, 1947, from the Plio-Pleistocene of the western Atlantic (Loxahatchee, Florida) seems to be close to *Haplocochlias*.

Haplocochlias means "*unadorned snail*", possibly alluding to the lack of conspicuous ornamentation noted by CARPENTER (1864) on the type species (*H. cyclophoreus*) on the teleoconch surface "*minutissime spiraliter striolata*". However, after examining the ornamentation in most of the species in this genus, we can conclude that the meaning of the word that defines the genus is not the most appropriate.

For a better identification and differentiation of the species studied, we have grouped them by morphological affinity. At the same time we have created an identification key with the intention of providing a useful tool for species determination.

Considering the morphology of their shells, and after a comparison with *Gottoina sulcifera* A. Adams, 1863, type species of the genus (Figs. 43 A-D), we have transferred to *Haplocochlias* two species described by DALL (1889): *Fossarus (Gottoina) bella* and *Fossarus (Gottoina) compacta,* both from the East coast of the United States.

The fundamental differences between the species of both genera are: the shell of *Gottoina* is imperforate, has an arched inner lip and the outer lip with a crenulated margin, all of which are characters not present in the species placed by Dall in *Gottoina*. One must consider that prior to the description of these two species, DALL (1889) wrote: "*We have now to add two small species, which seem to range from Florida to Cape Hatteras, having been obtained off the coast of North Carolina, in less than 100 fms (183 m), by the U. S Fish Commission. They appear to belong to the subgenus* Gottoina *of A. Adams, which is described as imperforate, solid, and ornamented with spiral sculpture. I have not seen a typical specimen of* Gottoina, *which, moreover, has not been figured, so I refer these species to it on account of their apparent relation to* Fossarus *and the description of* Gottoina *aforesaid*".

The fact that DALL (1889) admitted not having seen any typical specimen of

Gottoina and that it had not been figured, indicates that his inclusion of both species in the subgenus was based exclusively on the literal description.

For a better comparative study, we have separated the species into six groups based on morphological characters.

cyclophoreus group

Remarks: The species included in this group are mainly characterized by the robustness of the shell, by having a completely smooth protoconch, without spiral cordlets, and by a very thick aperture. With the exception of *Haplocochlias risoneideneryae*, all of them lack axial striae in the spaces between the teleoconch cords; only thin lines of growth that can be observed there.

Haplocochlias cyclophoreus Carpenter, 1864 (Figures 2, 3)

Haplocochlias cyclophoreus Carpenter, 1864. *Annals and Magazine of Natural History*, (3)13: 476. [Type locality: Cape St. Lucas, Pacific coast of Mexico].

Type material: Syntypes deposited in AMNH (nº 18112) and in NHMUK, in the Cuming Collection. Not examined.

Other material examined: Mexico, Pacific coast: 1 s, Punta Mita, Nayarit, West México (CHL); 17 s, Pulmo Bay, Baja California, 5-20 ft (1.5-6 m) on boulders and ledges, some coral (LACM 66-19); 18 s, Sayulita, about 23 miles (37 kms) north of Puerto Vallarta, Nayarit, intertidal (LACM 70-4); 7 s, El Chileno (Rancho El Tule), Baja California Sur, intertidal (LACM 70-52); 3 j, W side of Ceralvo Island, Baja California, 30-50 ft (9-15 m) (LACM 71-24); 11 s, Bahia Escondida, Baja California Sur, intertidal (LACM 71-31).

Description: Original description in Carpenter (1864: 476): "*Testa compacta, parva, solidiore; albida, sed pallide aurantiaca; anf. v., rapide augentibus, suturis impressis; tota superficie minutissime spiraliter striolata, nitida; apertura rotundata; peritremate continuo, incrassato, extus varicoso; labio distincto; axi t. jun. umbilicata, adultae lacunata. Long. 19, long. spir. 06, lat. 2 poll., div. 100°*". The best illustration is in Palmer (1958, pl. 65, figs, 1-2), two syntypes from Cape St. Lucas.

Shell turbiniform, globose, solid, of white-yellowish colour, spire formed by 4 ¾ rapidly-expanding whorls, separated by a distinct suture. The protoconch has almost ¾ whorl, is completely smooth, measuring about 220 μm in diameter and there is neither a varix nor any thickening at its terminus. The teleoconch has 4 spiral whorls, with spiral cords of regular size, scarcely prominent, which are distributed across shell; the spaces between cords are covered by microtubercles and by regularly-spaced axial grooves that disappear on the last whorl, leaving only growth lines. At the beginning of each whorl, we count 4 cords on the first, 7 on the second, 14 on the third, and about 42 at the beginning of the fourth. The aperture is rounded and the peristome continuous, very thick and slightly crenulated in the columellar area. The outer lip is thickened on its outer margin by the presence of spiral cords and rough, very tight growth lines. The reflection of the columella and a thin parietal callus almost close the umbilicus, which is delimited by a spiral cord and is reduced to a narrow fissure, with only growth lines inside. Some specimens show a strong parietal callus which is expanded and together with the columella totally closes the umbilicus (Fig. 3A-B).

Dimensions: height, 5 mm; diameter, 5.2 mm. The specimen photographed in Figure 2 measures 5.15 mm in height and 5.35 mm in maximum diameter.

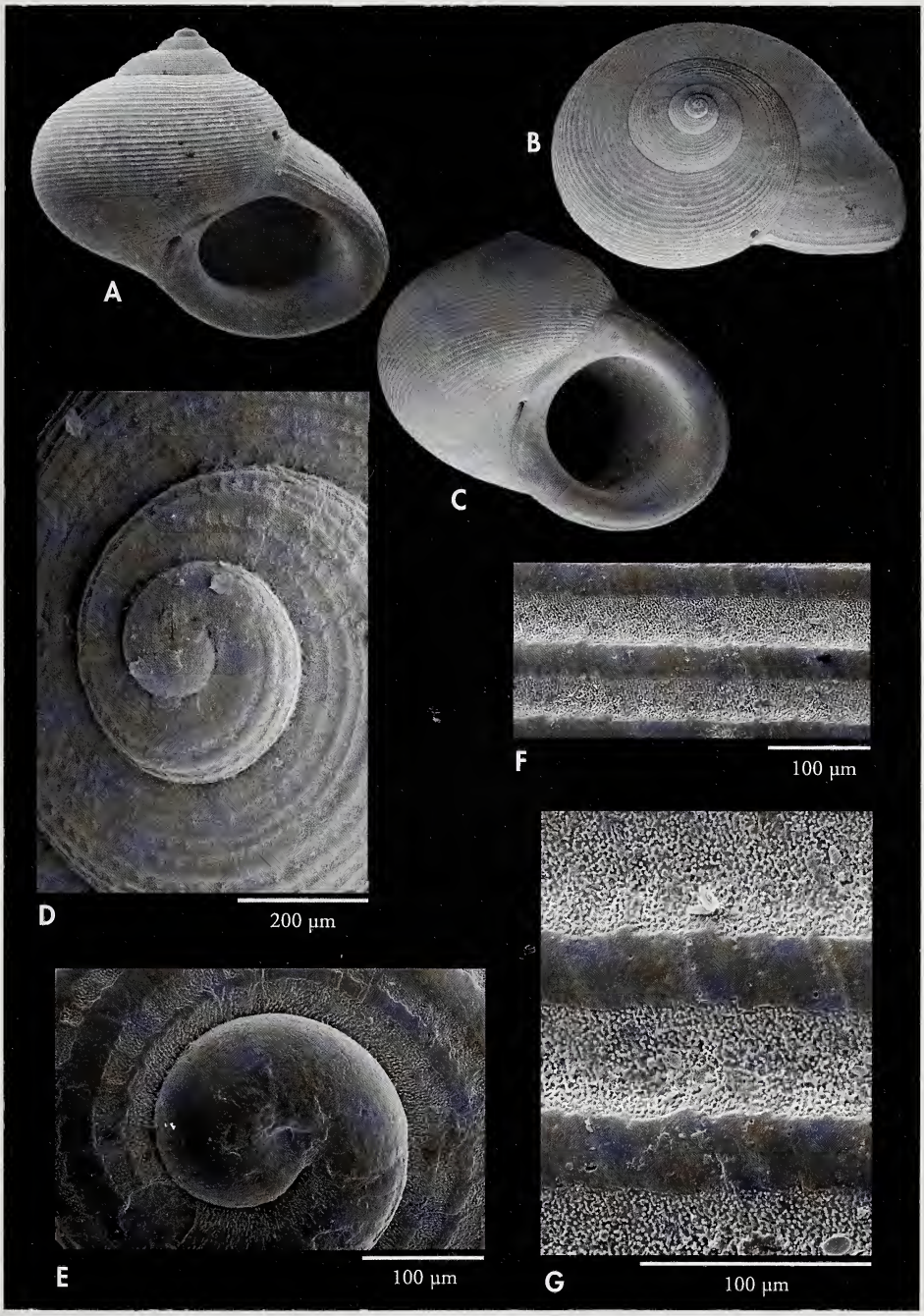

Figure 2. *Haplocochlias cyclophoreus* Carpenter, 1864. A-C: shell, 5.15 x 5.35 mm, Punta Mita, Nayarit, Pacific coast of Mexico (CHL); D: apical view; E: protoconch; F, G: microsculpture and detail of last whorl, same shell.

Figura 2. Haplocochlias cyclophoreus *Carpenter, 1864. A-C: concha, 5,15 x 5,35 mm, Punta Mita, Nayarit, costa pacífica de México (CHL); D: vista apical; E: protoconcha; F, G: microescultura y detalle de la última vuelta, misma concha.*

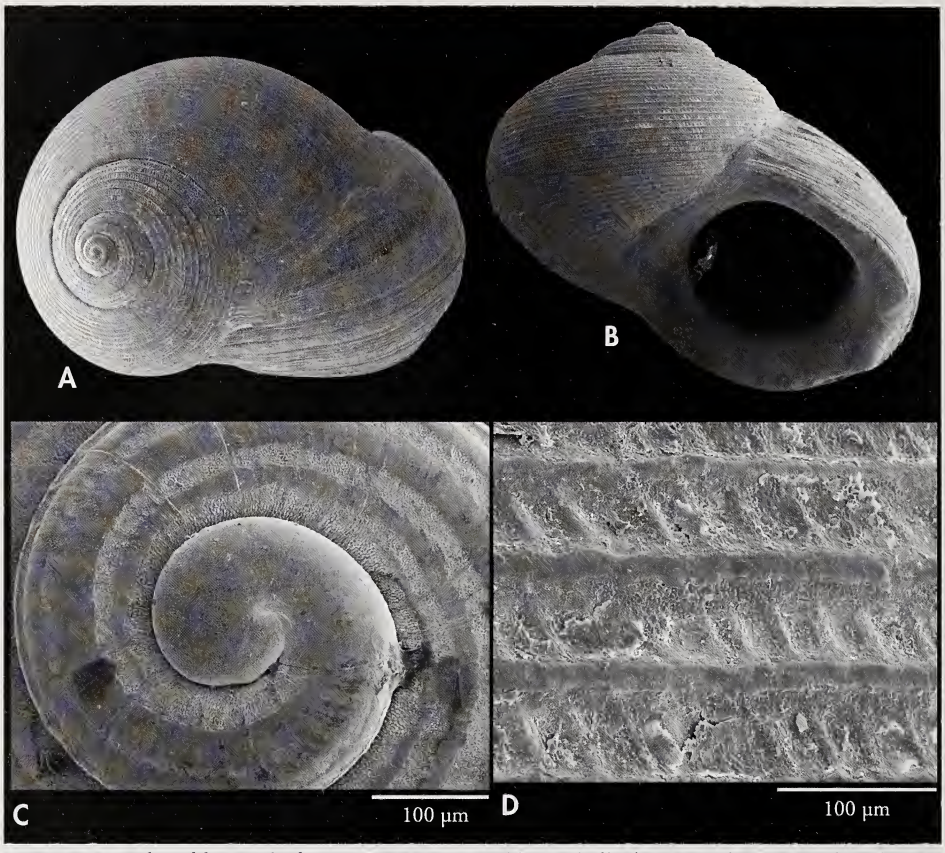

Figure 3. *Haplocochlias cyclophoreus* Carpenter, 1864. A: shell, diameter 4.75 mm, dorsal view, Escondida Bay, Baja California Sur, Mexico (LACM); B: shell, diameter 4.6 mm, apertural view, Pulmo Bay, Mexico; C: protoconch, same shell as A; D: microsculpture of the last whorl, same shell as B.

Figura 3. Haplocochlias cyclophoreus *Carpenter, 1864. A: concha, diámetro 4,75 mm, vista dorsal, Bahía Escondida, Baja California Sur, México (LACM); B: concha, diámetro 4,6 mm, vista apertural, Bahía Pulmo, Baja California, México; C: protoconcha, misma concha que A; D: microescultura de la última vuelta, misma concha que B.*

Habitat: Intertidal to 10 m (Keen, 1971). Under rocks, between 2 and 5 meters. The studied samples are in the most part intertidal, have been found down to 15 m deep; they live on boulders and ledges with some coral.

Distribution: Cape St. Lucas, Mexico (Carpenter, 1864). Magdalena Bay, Cape San Lucas and Espiritu Santo Island, Baja California; Tres Marias Islands and south to Banderas Bay, Jalisco, Mexico (Keen, 1971; Abbott, 1974).

Remarks: Carpenter (1864) remarked: "*When laid on its base, this shell resembles* Helicina; *but the mouth is more like* Cyclophorus. *The young shell is semi-transparent, and resembles a* Vitrinella *with thickened lip*".

In the absence of illustrations of the species described by Carpenter (1864), Palmer (1958) published a work that illustrated the type material of the species from the West Coast (San Diego to British Columbia), including the type locality and catalogue number of each.

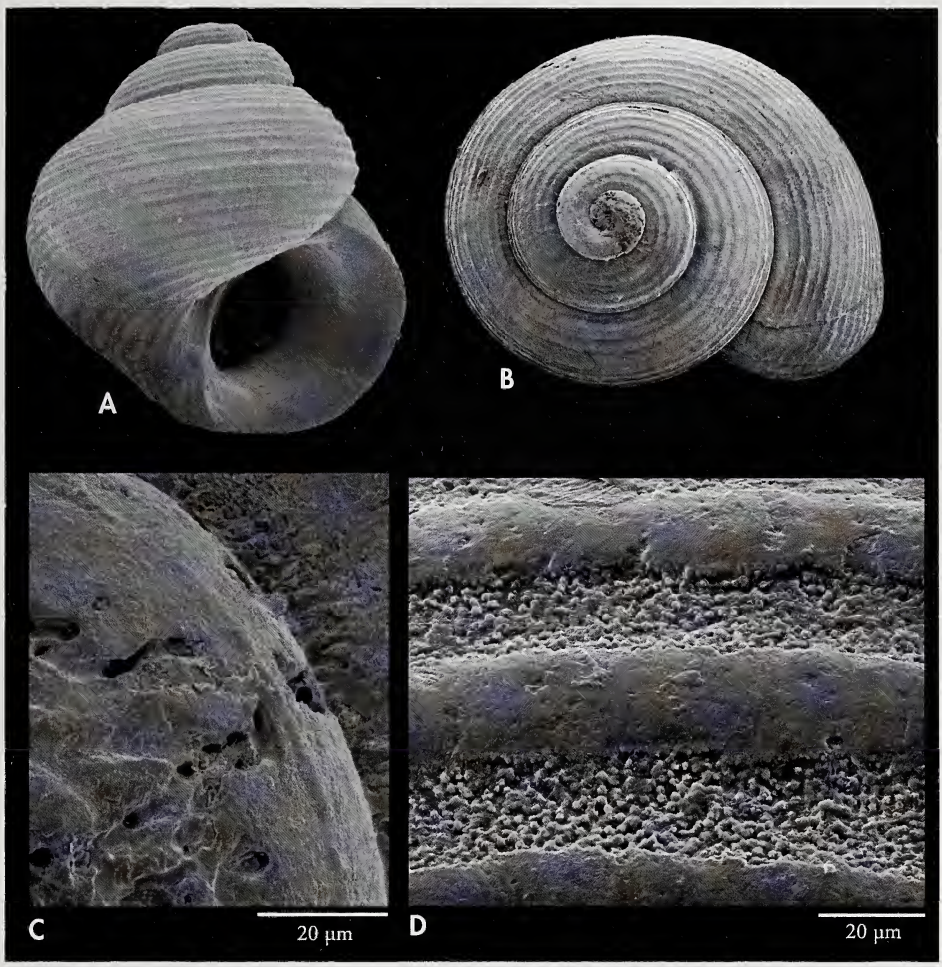

Figure 4. *Haplocochlias lucasensis* (Strong, 1934). A, B: shell, 1.60 mm in diameter, Cape San Lucas, Baja California, Mexico (CHL); C: partial view of the protoconch, same shell; D: microsculpture.

Figura 4. Haplocochlias lucasensis *(Strong, 1934). A, B: concha, 1,60 mm de diámetro, Cabo San Lucas, Baja California, México (CHL); C: vista parcial de la protoconcha, misma concha; D: microescultura.*

Given that *Haplocochlias cyclophoreus* is the type species of the genus by monotypy, it is essential to point out the characters that serve to identify the group and characterize the genus.

After the examination of numerous samples we could see that in the last ¾ of the last whorl the spiral cords are widening, the axial striae disappear and the interspaces between cords are reduced to narrow grooves, where only micro tubercles can be seen. The species is characterized by its external lip with growth lines close together on the border of the lip.

H. cyclophoreus differs from its congeners by its larger size, the solidity of its shell, its smooth protoconch, the regularity and size of the spiral cords and their interspaces, by the characteristic thickened lip and its umbilicus, reduced to a small slit.

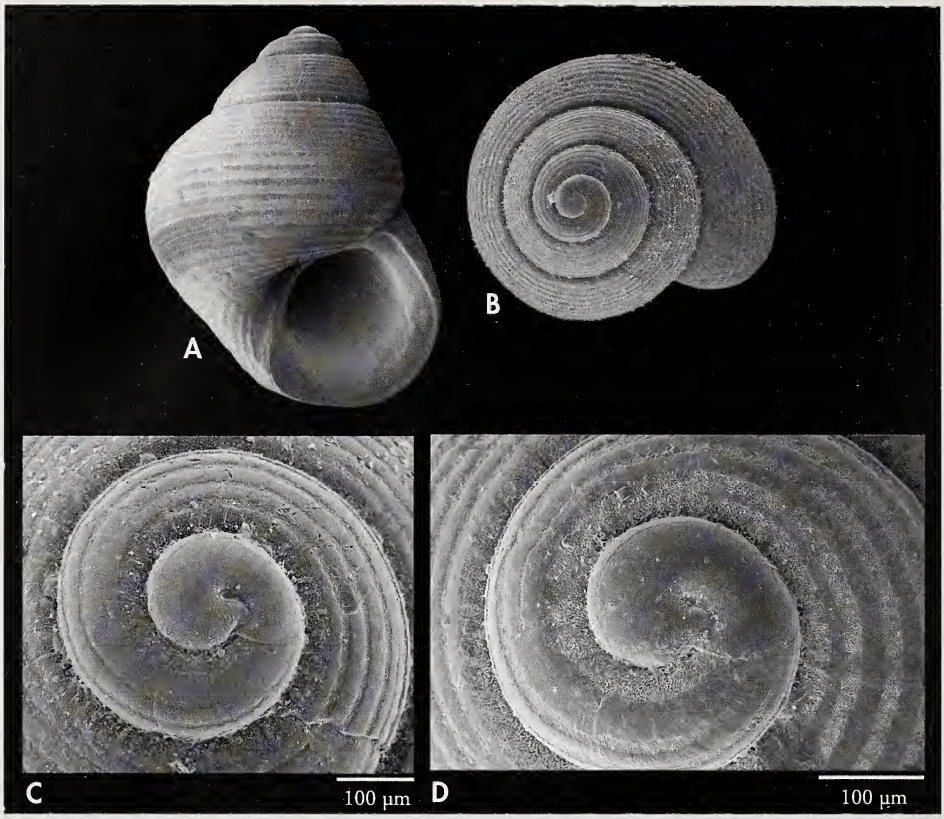

Figure 5. *Haplocochlias lucasensis* (Strong, 1934). A, B: shell, diameter 1.60 mm, Pulmo Bay, Baja California, Mexico (LACM 66-19); C: protoconch, same shell; D: protoconch of a juvenile.
Figura 5. Haplocochlias lucasensis *(Strong, 1934). A, B: concha, diámetro 1,60 mm, Bahía Pulmo, Baja California, México (LACM 66-19); C: protoconcha, misma concha; D: protoconcha de un juvenil.*

Haplocochlias lucasensis (Strong, 1934) (Figures 4, 5)

Liotia lucasensis Strong, 1934. *Transactions of the San Diego Society of Natural History*, 7 (37): 441, pl. 29, figs. 10-12. [Type locality: Cape San Lucas, Baja California, Pacific coast of Mexico].

Type material: Holotype in California Academy of Sciences (nº 5477). Not examined.
Other material examined: Mexico, Pacific coast: 1 sp, Cape San Lucas, Baja California, undersides of rocks at low tide line (CHL); 19 s, Rancho El Tule, Canelo Bay, Baja California, intertidal on rock boulders and ledges (LACM 66-15); 7 s, Rancho El Tule, Canelo Bay, Baja California, 15-30 ft (4.5-9 m), on large boulders and in rock crevices (LACM 66-16); 42 s, Pulmo Bay, Baja California, 5-20 ft (1.5-6 m), on boulders and ledges, some coral (LACM 66-19); 16 s, Isla de San Pedro Nolasco, Sonora, outside rock at south tip at 30-75 ft (9-23 m) (LACM 67-4); 5 s, W side of Ceralvo Island, Baja California, 15-20 ft (4.5-6 m) (LACM 71-25).

Description: This is the original description by Strong (1934): "*Shell minute, globose, shining white, of about three and a half slightly shouldered whorls and a very minute flattened nucleus of a little over one whorl; sutures not excavated; spiral sculpture of fine, raised, smooth, spiral threads, of which four appear on the first*

whorl, eight on the second and about twenty on the body whorl; axial sculpture absent; aperture circular, with a thick, continuous lip; umbilicus small. The type, which is one of about 200 more or less beach worn specimens, comes from Cape San Lucas and measures: height, 1.7; maximum diameter, 1.6 mm".

The protoconch has 3/4 whorl and a maximum diameter of 220 μm. Despite the poor condition of the protoconch of the shell studied, we were able to observe a spiral cord (Fig. 4C) close to the suture. For this reason we have inferred that this species, like its congeners, has spiral cords on the protoconch.

Teleoconch with 3 whorls; ornamentation formed by slightly prominent spiral cords, narrower than their interspaces, no axial grooves, but numerous microtubercles completely covering the spaces between cords. There are 21 spiral cords at the beginning of the last whorl. Aperture rounded; columella arched, not reflected; outer lip with a sharp border, very thick inside, not crenulated. Umbilicus narrow and deep, fusiform, in its interior there are several growth lines.

Dimensions: holotype 1.7 mm high, 1.6 mm in diameter. Our material is similar in size.

Habitat: Intertidal to 10 m (KEEN, 1971; ABBOTT, 1974). The studied specimens were distributed between intertidal and infralittoral areas, and their bathymetric range between 0 and 75 ft (23 m), on rock boulders and ledges and in rock crevices.

Distribution: Recorded from Cape San Lucas, Baja California, Mexico (STRONG, 1934); from San Pedro Nolasco Island and Guaymas, south to Cape San Lucas and Socorro Island, Revillagigedo Islands, Mexico (KEEN, 1971) and Gulf of California (ABBOTT, 1974).

Remarks: *Haplocochlias lucasensis* was described in the genus *Liotia*, and its author STRONG (1934) stated: *"This minute species would seem to be entirely distinct from any of the other west coast species placed in the genus"*.

KNIGHT *ET AL.* (1960) placed it in *Haplocochlias*, considering the morphological characters of its shell quite similar to those of *H. cyclophoreus*. Indeed, *H. lucasensis* is very similar in its ornamentation and lip thickening to *H. cyclophoreus*, but it differs by its smaller size and less globose spire. Another species which presents a certain affinity in ornamentation is *H. cubensis*, but, in addition to the geographical distribution, the latter has a larger number of the spiral cords on the teleoconch whorls.

Haplocochlias compactus (Dall, 1889) (Figure 6)

Fossarus (Gottoina) compacta Dall, 1889. *Bulletin of the Museum of Comparative Zoology*, 18: 273, pl. 28, fig. 6. [Type locality from lectotype: Off Havana, Cuba, 153 m].

Type material: Syntype in MCZ (7462) here designated as lectotype, from off Havana, Cuba, 84 fathoms (153 m), examined. Nine paratypes from USFC sta. 2596 in USNM (94910), not examined. **Other material examined**: USA: 1 s, (28° 4.57′ N-90° 59.99′ W), Louisiana, dredged at 87.9 m (CHL); 1 s, station D-1 (28° 3.43′ N-92° 26.97′ W), Louisiana, dredged at 71-74 m (CHL); 2 s, off Sombrero Light, Key Vaca, Monroe Co., Florida, dredged at 67 m (CHL); 1 s, station BIERFK-419, Carysfirt reef, Florida Keys, Monroe Co., Florida, 79 m (FMNH, 333903); 1 s, station BIERFK-447, Key Colony Beach, Florida Keys, Monroe Co., Florida, 77 m (FMNH, 333881); 1 s, station BIERFK-445, Key Colony Beach, Florida Keys, Monroe Co., Florida, 57 m (FMNH, 333914).

Description: Original description in DALL (1889): *"Shell small, white, compact, elevated, spirally sculptured, of about four and a half whorls including the nucleus; outline of the spire convex with hardly any rounding in of the whorls toward the suture, which is nevertheless distinct and finely channelled. Radiating sculpture none, lines of growth not visible; spiral sculpture of fine, close, even, rounded threads, growing gradually smaller from the suture forward; there is no secondary grooving; there are about*

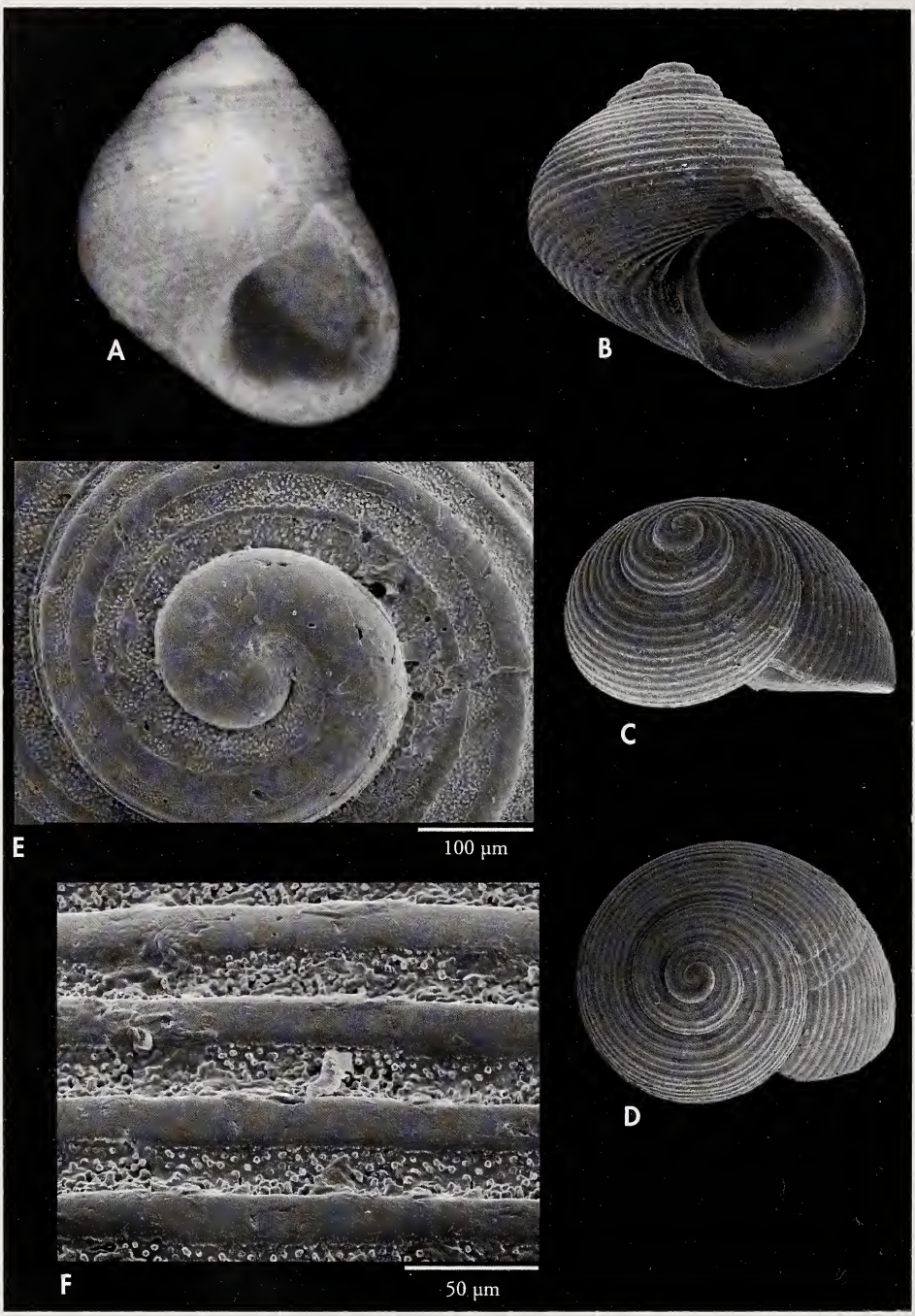

Figure 6. *Haplocochlias compactus* (Dall, 1889). A: Lectotype of *Fossarus (Gottoina) compacta* Dall, 1889 (MCZ-7462); B-D: shell, diameter 1.70 mm, Louisiana, USA (28º 4.57' N-90º 59.99' W) (CHL); E: protoconch, same shell as D; F: microsculpture, same shell.

Figura 6. Haplocochlias compactus *(Dall, 1889). A: Lectotipo de* Fossarus (Gottoina) compacta *Dall, 1889 (MCZ-7462); B-D: concha, diámetro 1,70 mm, Louisiana, EE. UU. (28º 4,57' N-90º 59,99' W) (CHL); E: protoconcha, misma concha que D; F: microescultura, misma concha.*

twenty-five threads on the last whorl, but they vary in number and strength with the individual specimen; base full and rounded, imperforate; aperture rounded, pointed behind, and the angle filled with callus; callus continuous, thinnest on the columella. Alt. 2.3 mm.; max. diam. 2.0 mm."

Additional description: The protoconch has somewhat more than ¾ whorl, it measures about 220 μm in diameter and is completely smooth. Teleoconch composed of 2 ¾ whorls completely covered by spiral cords, usually narrower than their interspaces, which appear totally covered by microtubercles. In apertural view the examined shells have 21 and 23 spiral cords in the last whorl. Columella and outer lip reflected outward. At the confluence with the outer lip, the columella and umbilical cord become slightly expanded. Within the umbilicus, 1-2 cordlets can be seen.

Dimensions: Maximum reported size: 2.3 mm. The shell examined is 1.63 mm in height and 1.70 mm in diameter (H/D: 0.96).

Habitat: Based on the known bathymetric information, this is a species that lives in the circalittoral level, between 57 and 80 m depth, having also been found on the continental slope, between 89 and 195 m deep.

Distribution: USA: USFC sta. 2595, 2596, 2612, off North Carolina, 35.14°N to 23°N; 97°W to 75.09°W (DALL, 1889); Texas (ODÉ, 1987); Off North Carolina, and Florida Keys (ABBOTT, 1974). Cuba: Off Havana (type locality, leg. Sigsbee).

Remarks: The syntype of *Fossarus (Gottoina) compacta* Dall, 1889 (MCZ, 7462) (Fig. 6A), here designated as lectotype, is an adult specimen larger than those examined in the present work and which agrees with the original description in appearing imperforate. This seems due to the widening and reflection of the columella which close the umbilicus totally. In contrast, the studied samples are smaller and, even being adult, present a reduced umbilicus, and probably only in senile specimens, due to the larger size and reflection of the columella, the umbilicus becomes totally closed. This situation could be observed also in other species of the genus.

In our opinion, *Fossarus (Gottoina) compacta* should be moved to the genus *Haplocochlias* because of its similarity to *H. cyclophoreus* and *H. lucasensis*. The solidity of the shell, the completely smooth protoconch and a teleoconch entirely covered by spiral cords which lack axial grooves in their interspaces, support its transfer to *Haplocochlias*.

Haplocochlias risoneideneryae Barros, Santos, Santos, Cabral & Acioli, 2002 (Figure 7)

Haplocochlias risoneideneryae Barros, Santos, Santos, Cabral & Acioli, 2002. *Boletim Tecnico Cientifico do CEPENE*, 10 (1): 44, fig. 4 A-D. [Type locality: Fernando de Noronha, Pernambuco, Brazil].

Type material: 11 specimens in Museu de Malacologia da UFRPE (nº 7601). Not examined.
Material examined: Brazil: 2 s, off north Natal, Rio Grande do Norte State, taken in coral sand at 15-25 m (CHL).

Description: Original description in BARROS *ET AL.* (2002): "*Concha pequena, turbinada. Protoconcha formada por uma volta e meia aproximadamente, de contornos amplamente convexos e de aspecto liso. Núcleo evidente, plano. Espira baixa, ornada por várias cordas espirais fortes e um ombro conspícuo. Umbílico parcialmente fechado, lábio externo espesso, abertura arredondada, sutura pouco profunda, não canaliculada; linhas de crescimento e cicatrizes pouco evidentes. Anfractos inflados fortemente convexos.*

Ornamentação axial inconspícua. Base curta e afilada desta com a parede umbilical. Diâmetro máximo: 4,2 mm".

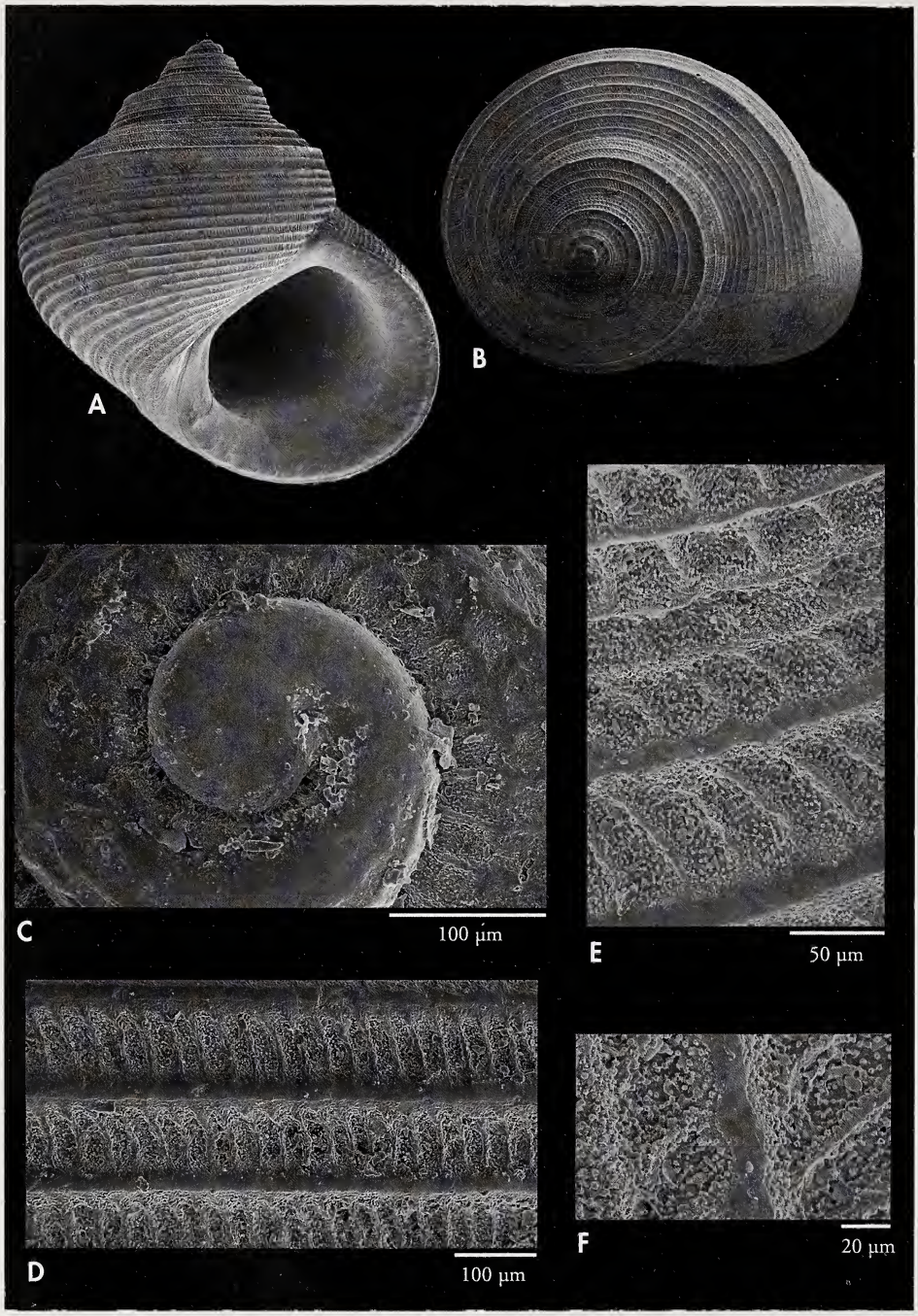

Figure 7. *Haplocochlias risoneideneryae* Barros, Santos, Santos, Cabral & Acioli, 2002. A, B: shell, 4.52 × 4.30 mm, Rio Grande do Norte, Brazil (CHL); C: protoconch, same shell; D-F: microsculpture from the middle part of the last whorl.

Figura 7. Haplocochlias risoneideneryae *Barros, Santos, Santos, Cabral & Acioli, 2002. A, B: concha, 4,52 × 4,30 mm, Rio Grande do Norte, Brasil (CHL); C: protoconcha, misma concha; D-F: microescultura de la parte mediana de la última vuelta.*

The largest examined specimen measures 4.52 mm in height and 4.30 mm in diameter, and its spire is formed by 5 ¼ rapidly expanding whorls. The protoconch has ¾ whorl and is totally smooth, measuring about 200 μm. The teleoconch is formed by 4 ½ whorls, completely covered by spiral cords, with axial growth marks and microtubercles in the interspaces. In the apertural view 3-4 cords can be seen on the first whorl, 5 on the second, 8 on the third and 24 on the last one. The interspaces are wider than the cords and are completely covered by very closely placed fine axial grooves, especially on the last whorl. In the last half whorl, a fine spiral cordlet arises between the spiral cords, so the number of cords on the outer lip is much greater. Aperture rounded, slightly prosocline; outer lip very thick; many spiral cords on its external margin and a strong thickened lip can be observed, and on its inner margin there is fine denticulation; columella very wide at its base and reflected towards the umbilicus, covering it completely; parietal area covered by a thin callous coat.

Habitat: The type material comes from intertidal sediments. Other material examined was collected at depths between 15 and 25 m.

Distribution: Brazil: Fernando de Noronha, Pernambuco, Natal, and Rio Grande do Norte States.

Remarks: In its general appearance *Haplocochlias risoneideneryae* is quite similar to *H. cyclophoreus*, being oblong, thick, and having a very thickened outer lip, the protoconch being totally smooth. *Haplocochlias risoneideneryae* may be distinguished from *H. cyclophoreus* by having the umbilicus completely covered and the spaces between cords ornamented with fine axial striae which, on the last whorl, become very numerous; also its spire is more angulate. Despite being one of the larger species, the diameter of its protoconch is the smallest among the known species.

Until its description as a new species, *H. risoneideneryae* was identified as *H. swifti*. BARROS *ET AL.* (2002), in their figure 3 represent the supposed holotype of *H. swifti* Vanatta, 1913 for comparison; however, that figure is neither *H. swifti* nor the holotype (ANSP 10292). It is the shell shown in ABBOTT (1974, fig. 457) as *H. swifti*, but, by from its morphological characters, mainly the shape of the lip, it is probably *H. nunezi* or *H. moolenbeeki*. BARROS *ET AL.* (2002), in failing to verify the type material, perpetuated the error of ABBOTT (1974).

Haplocochlias multiliratus spec. nov. (Figure 8)

Type material: Holotype in LACM (3260) (Figs. 8A-B).
Other material examined: None.
Type locality: Small islets off Quepos, Puntarenas province, Costa Rica (9° 22′ 12″N-84° 09′ 15″W), 75 ft (23 m), gravel and cobble.
Etymology: The specific name alludes to the numerous cordlets of its sculpture.

Description: Shell of very small size, globose, turbiniform, wider than high (H/D: 0.82), spire formed by 3 ¾ rapidly increasing whorls. The protoconch has ¾ of whorl, is apparently smooth, measures 190 μm and finishes in a varix. The teleoconch has 3 spiral whorls and is ornamented by spiral cords, axial striae and micro tubercles. In apertural view 3-4 cords on the first whorl can be seen, following with 5 on the second and 20-21 on the last one; from these, the upper 5 are more prominent and at the same time narrower than their interspaces, while the others are as wide as their interspaces. Distinct axial striae which do not form lamellae are distributed regularly in the spaces between the cords, except on the last half whorl, where the interspaces are narrower and the striae disappear, only being appreciable the micro tubercles.

Aperture rounded, prosocline; peristome continuous. Parietal area covered

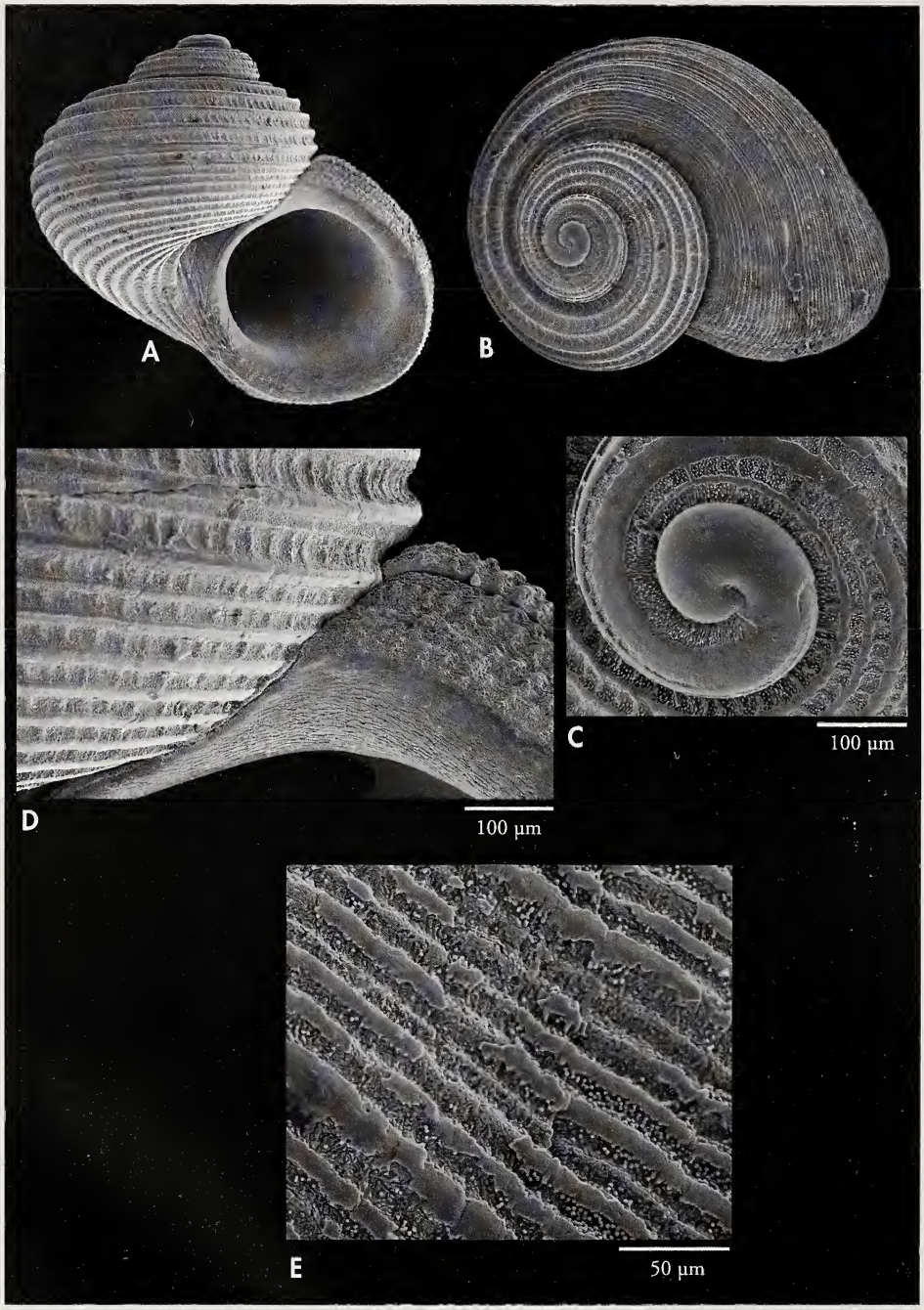

Figure 8. *Haplocochlias multiliratus* spec. nov. A, B: holotype, diameter 1.94 mm, small islets off Quepos, Puntarenas province, Costa Rica; C: protoconch, apical view of the holotype; D, E: ornamentation detail of the last whorl, near the base.

Figura 8. Haplocochlias multiliratus *spec. nov. A, B: holotipo, diámetro 1,94 m, islotes frente a Quepos, provincia de Puntarenas, Costa Rica; C: protoconcha, vista apical del holotipo; D, E: detalle de ornamentación de la última vuelta, cerca de la base.*

by a strong callous coating; columella almost straight, wide, amplified at its base, not reflected towards the umbilicus; external lip very wide, not denticulate inside or crenulated in spite of the numerous spiral cordlets that originate on the last half whorl. Umbilicus wide, deep, delimited by a strong spiral cord; in its interior 5-6 spiral cordlets and marked growth lines can be seen.

Dimensions: The holotype measures 1.94 mm in diameter and 1.69 mm in height.

Habitat: An infralittoral species which lives in gravel and cobble bottoms.

Distribution: Only known from the type locality.

Remarks: *Haplocochlias multiliratus* spec. nov. is a species very similar to *H. cyclophoreus* in its general shape, but different by the smaller size of shell and protoconch, larger number of spiral cordlets on the last half whorl and also because in this part the spaces between cords are narrower and the axial striae become grooves; also by the more open umbilicus with fine cordlets inside.

It differs from *H. lucasensis* and *H. compactus* by having strong axial striae in the interspaces between the cords over all the shell. From *H. risoneideneryae* it may be distinguished by its smaller size and by the presence on the last half whorl of more of 50 spiral cordlets.

swifti group

Remarks: The species comprised in this group have a very thick and internally crenulated outer lip, the umbilicus reduced to a small fissure and the periphery of the shell angled by the presence of thick and prominent spiral cords.

Haplocochlias swifti Vanatta, 1913 (Figures 9, 10)

Haplocochlias swifti Vanatta, 1913. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 65: 23-24, fig. 3. [Type locality: St. Thomas, Virgin Islands].

Type material: Holotype in ANSP (10292).
Material examined: USA: 2 s, rocky reef, 45 m, Palm Beach, Florida (MCZ, 207094); 1 s, Off Palm Beach, Florida, 54 m (MCZ 226853). Cuba: 1 s, Cable Inglés, Cienfuegos, in sediment from 31 m depth (MHNS); 1 s, Bahía de Cienfuegos, 20-30 m (MHNS); 1 s, 3 j, Rancho Luna Beach, Cienfuegos (MHNS).

Description: Original description in VANATTA (1913: 23-24): *"Shell small, umbilicate, turbinate, white, suture deeply impressed, spire elevated, whorls 5, very convex, contabulate, the first whorl somewhat eroded, the two following whorls bicarinate, the penultimate and body whorl more or less tricarinate. The body whorl is sculptured with 24 spaced spiral striae with microscopic vertical striae in the interstices. The fourth, sixth and eighth striae below the suture on the body whorl are larger than the others and three or four striae near the umbilicus are closer together. The umbilicus is of moderate size. The aperture is orbicular, peristome continuous, very thick, and broadly reflexed, crenate, parietal callus thick, columella narrow above and broad at the base, bearing a median groove.*

Length 3.92, diameter 3.92 mm".

The protoconch (Fig. 9C, 10C), barely ¾ of whorl, is smooth and measures about 220 μm. Ornamentation consists of spiral cords, axial ribs and microtubercles in the spaces between cords. First and second whorls of the teleoconch are bicarinate; third and last round to tricarinate. On the last whorl there are 24 spiral cords, of which the 4th, the 6th and 8th are more prominent. The spaces between cords (Figs. 9D, 10D-E) have fine axial ribs, slightly prosocline and regularly spaced, forming small quadrangular cells whose

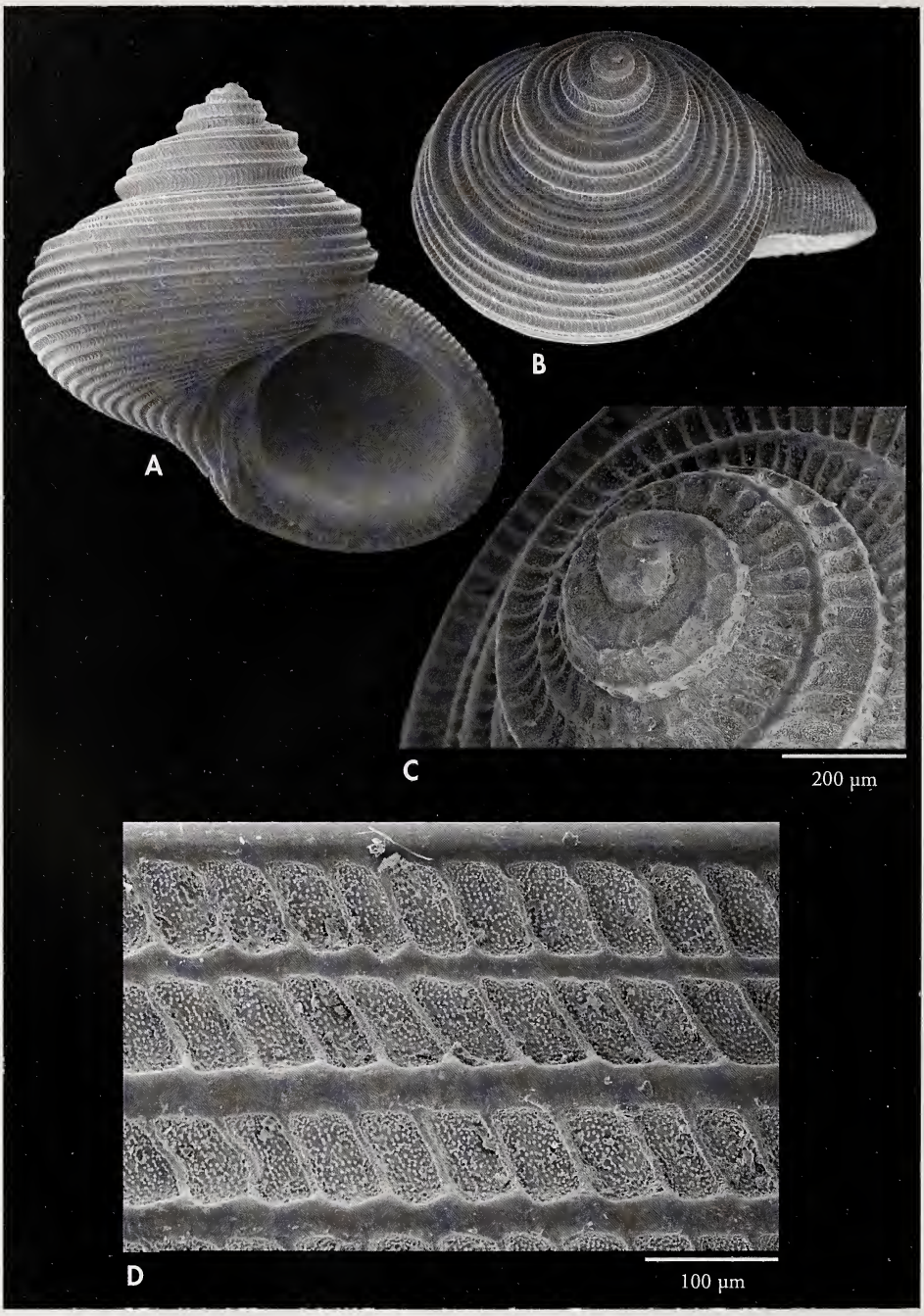

Figure 9. *Haplocochlias swifti* Vanatta, 1913. A, B: adult shell, diameter 3.7 mm, Rancho Luna Beach, Cienfuegos, Cuba (MHNS); C: protoconch of this shell; D: microsculpture of the last whorl.

Figura 9. Haplocochlias swifti *Vanatta, 1913. A, B: concha adulta, diámetro 3,7 mm, Playa Rancho Luna, Cienfuegos, Cuba (MHNS); C: protoconcha de la misma concha; D: microescultura de la última vuelta.*

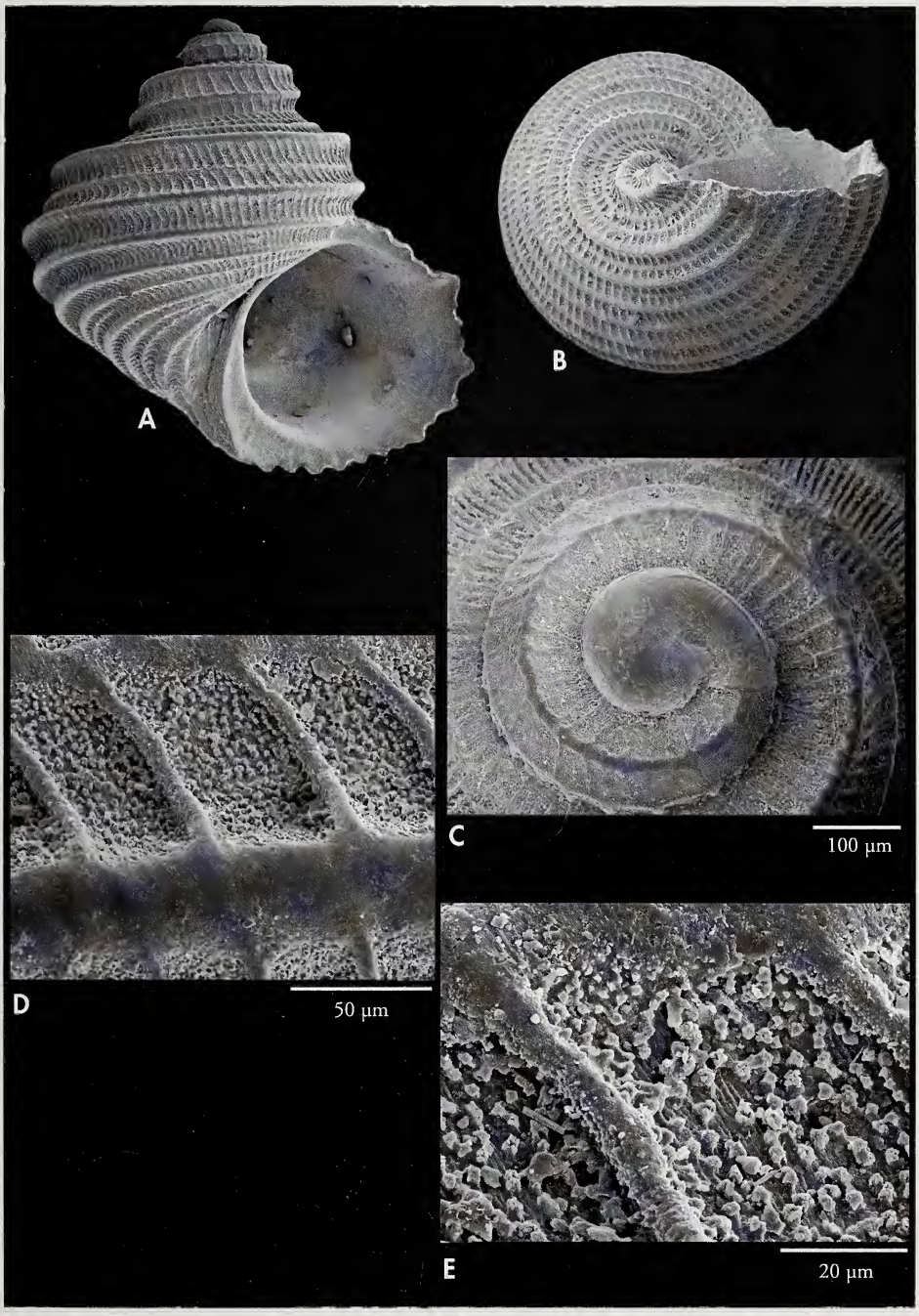

Figure 10. *Haplocochlias swifti* Vanatta, 1913. A, B: immature shell, diameter 1.6 mm in diameter, Rancho Luna Beach, Cienfuegos, Cuba (MHNS); C: protoconch of this shell; D, E: microsculpture of the last whorl and detail.

Figura 10. Haplocochlias swifti *Vanatta, 1913. A, B: concha inmadura, diámetro 1,6 mm, Playa Rancho Luna, Cienfuegos, Cuba (MHNS); C: protoconcha de la misma concha; D, E: microescultura de la última vuelta y detalle.*

surface is covered by microtubercles which cover neither the axial ribs nor the spiral cords. The umbilicus is limited to a narrow fissure. Aperture rounded; peristome continuous, very thick; columella and outer lip reflected outwards, inner aspect crenulated.

Dimensions: Large specimens can reach 6 mm in diameter.

Habitat: From 5 down to 45 m in depth (DE JONG & COOMANS, 1988). On a bottom of sand and coral gravel down to 45 m in depth (DÍAZ MERLANO & PUYANA HEGEDUS, 1994). In sandy/muddy bottoms to 4 m deep and near reefs at 8 m depth; in bottoms covered by a thin yellowish-tan layer of mucus from the corals (information of the material deposited in the UCR) (RODRÍGUEZ SEVILLA *ET AL.*, 2003). In Cienfuegos, Cuba, it was found on a bottom of coralline sand to 31 m depth.

Distribution: Saint Thomas, Virgin Islands (VANATTA, 1913). Havana, Cuba (PILSBRY & AGUAYO, 1933). Bocas del Toro Is., Panamá (OLSSON & MCGINTY, 1958; ABBOTT, 1974). Fernando de Noronha (RÍOS, 1985). Curaçao and Bonaire (DE JONG & COOMANS, 1988). From the Greater Antilles and Panama to Brazil (DÍAZ MERLANO & PUYANA HEGEDUS 1994). Between Cahuita and Gandoca, Costa Rica (ESPINOSA & ORTEA, 2001).

Remarks: *H. swifti* was the first species of this genus to be described from the western Atlantic. The photographed specimen (Fig. 9A-B), 3.7 x 3.7 mm, has 5 spiral whorls and fully agrees with the description and original figuration.

VANATTA (1913) wrote: "*This species differs from* Haplocochlias cyclophoreus *Carpenter, 1864 by having coarser spiral sculpture, by having a more reflexed lip, and by being umbilicate*". We must bear in mind that *H. cyclophoreus* is a species of the American Pacific, that except for its conchological similarity, has little to do with *H. swifti*. The comparison drawn by these authors was based on it being the type species and only known congener.

ABBOTT (1974, nº 457) figured a shell of *H. moolenbeeki* as *H. swifti*.

RODRÍGUEZ, VARGAS & CORTÉS (2003) wrote: "*the specimen mentioned by* ROBINSON *&* MONTOYA *(1987) as* Haplocochlias swifti *is* H. costaricensis *(Robinson 1991)*". However, the taxon *Haplocochlias costaricensis* is included by ROBINSON (1991) in his Doctoral dissertation "The systematics and paleoecology of the prosobranch gastropods of the Pleistocene Moín formation of Costa Rica", Tulane University, New Orleans, Louisiana. It is here considered an unavailable name due to lack of publication of this thesis. This taxon appears to have been cited only once, in RODRÍGUEZ SEVILLA *ET AL.* (2003), a publication dealing with the marine gastropod molluscs of the Caribbean coast of Costa Rica.

Haplocochlias onaneyi Espinosa, Ortea & Fernández-Garcés, 2005 (Figure 11)

Haplocochlias onaneyi Espinosa, Ortea & Fernández-Garcés, 2005. *Avicennia*, 17: 72, figs. 1A-C. [Type Locality: Alamar, Havana, Cuba].

Type material: Holotype of *H. onaneyi* in IES, CITMA, Havana.
Material examined: Cuba: 1 s, María la Gorda, Guanahacabibes, 31 m, coralline sand (MHNS).

Description: Original description of *H. onaneyi* in ESPINOSA, ORTEA & FERNÁNDEZ-GARCÉS (2005): "*Concha robusta, de menor tamaño que H. swifti, de color blanco, espira formada por 4 vueltas de rápido crecimiento. Protoconcha con 3/4 de vuelta de espira, tiene 3 cordoncillos espirales y mide 237 µm de diámetro y presenta una gruesa variz labial. Teleoconcha formada por 3 1/4 vueltas, ornamentada con cordones espirales y estrías axiales y micropits en los espacios entre cordones. Se observan 2 cordones en la primera vuelta, 4 en la segunda y 18-19 cordones es la última. Las*

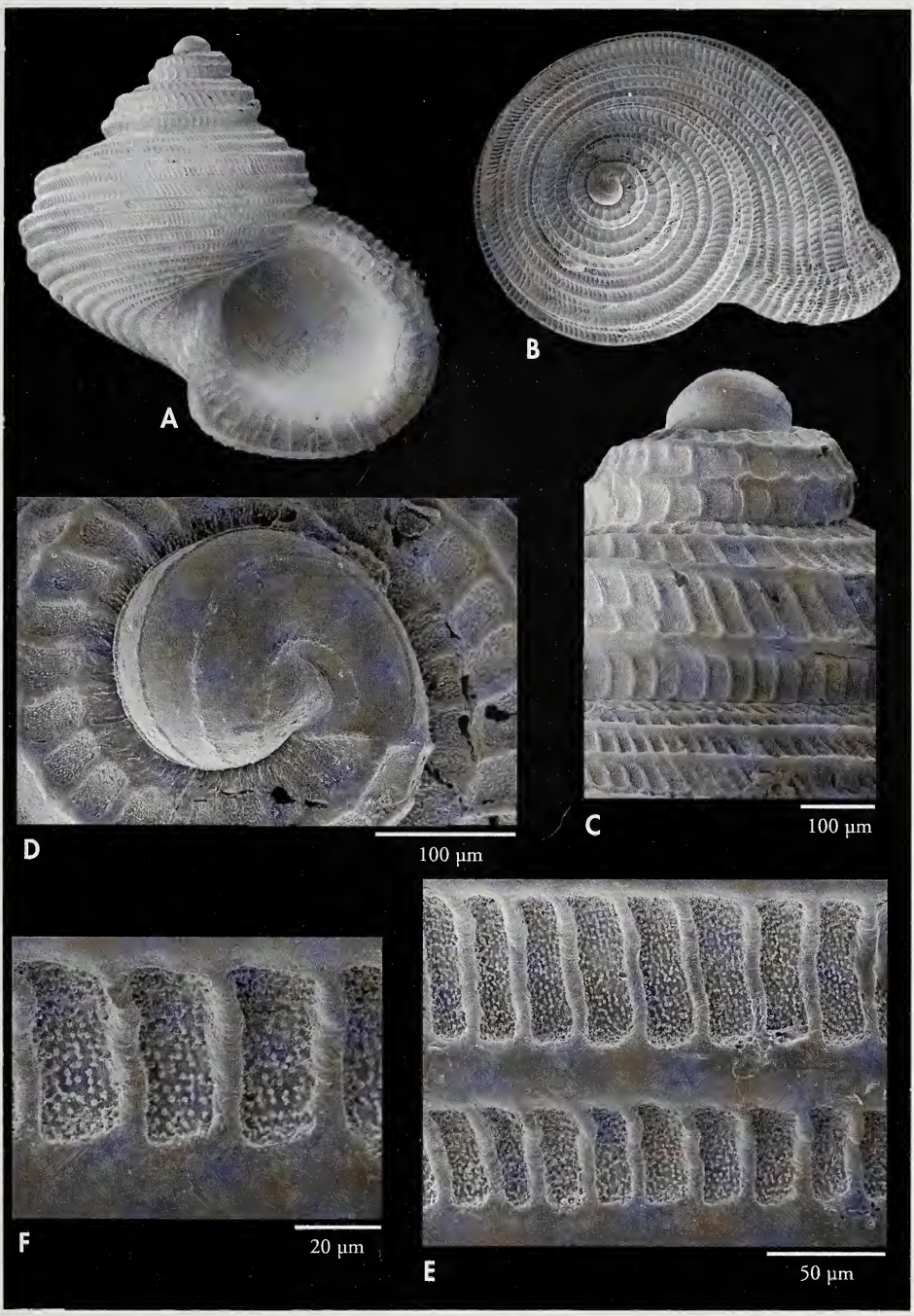

Figure 11. *Haplocochlias onaneyi* Espinosa, Ortea & Fernández-Garcés, 2005. A, B: shell, diameter 1.93 mm, María la Gorda, Guanahacabibes, Cuba (MHNS); C, D: protoconch of this shell; E-F: microsculpture of the last whorl.

Figura 11. Haplocochlias onaneyi *Espinosa, Ortea & Fernández-Garcés, 2005. A, B: concha, diámetro 1,93 mm, María la Gorda, Guanahacabibes, Cuba (MHNS); C, D: protoconcha de la misma concha; E-F: microescultura de la última vuelta.*

estrías espirales en la primera vuelta forman celdillas cuadrangulares, en la segunda y última vuelta, las estrías se vuelven más numerosas y las celdillas tienen forma rectangular, y el espacio que delimitan aparece totalmente cubierto por micropits. Ombligo estrecho, profundo, ligeramente ocluido por la reflexión de la columela, hacia su interior penetran 2-3 cordoncillos. Abertura redondeada, peristoma continuo; labio externo muy grueso, frontalmente ensanchado, con crenulaciones (de 2 en 2) en su interior; la columela se ensancha hacia su base y se refleja exteriormente formando un ángulo característico; zona parietal cubierta por una delgada capa callosa".

Shell robust, smaller in size than *H. swifti*, white in colour, spire formed by 4 rapidly expanding whorls. Protoconch 3/4 whorls, with 3 spiral cordlets, measuring about 240 μm in diameter, and having thick lip varix. Teleoconch composed of 3 1/4 whorls, ornamented by spiral cords and axial grooves with micropits in the spaces between them. There are 2 cords in the first whorl, 4 in the second and 18-19 cords is the last one. The spiral grooves on the first whorls form irregular cells, and on the second and the last whorl, the cells become more numerous and rectangular in shape, while the delimited space appears completely covered by microtubercles. Umbilicus narrow, deep, slightly occluded by the reflection of the columella, and with 2-3 cordlets penetrating towards its interior. Aperture rounded, continuous peristome; outer lip very thick, frontally expanded, with denticulations inside (by pairs); the columella widens towards its base and is reflected outwardly forming a characteristic angle; parietal area covered by a thin layer of callus.

Dimensions: Maximum reported size: 2.1 mm. The studied specimen measures 1.93 mm in height and 1.91 mm in maximum diameter.

Habitat: The holotype of *C. onaneyi* was found alive in Alamar, Havana, Cuba, inside a small cave at 17 m depth. The other 2 shells found (paratypes) come from sandy sediment collected at Rancho Luna Beach, Cienfuegos, at 54 m, and at Playa Varadero, Matanzas, at 15 m. The photographed specimen was found in sediment from a coralline sand bottom at 30 m depth at María la Gorda (West Cuba).

Distribution: Cuba: North Havana, North Matanzas, Cienfuegos Provinces (Espinosa, Ortea & Fernández-Garcés, 2005).

Remarks: Espinosa, Ortea, Fernández-Garcés & Moro (2007, fig. 006) refigured *H. onaneyi* showing a better depiction of the original apertural view.

Rosenberg (2013) indicates that from the figures, *H. onaneyi* seems to be a synonym of *H. williami*. However, after carefully examining the illustrations of *H. williami*, in our opinion, it is not the same species: the periphery of the shell is strongly angled, forming a characteristic shoulder; also the latter differs in the number of spiral cords. *H. onaneyi* may be distinguished from the other species of the group by the number of spiral cords of the last whorl and the characteristic aperture.

Haplocochlias garciai spec. nov. (Figure 12)

Type material: Holotype deposited in USNM (1 s, ex-CEG).
Type locality: East side entrance to Caribe Point Bight, S. Roatán Island, Honduras, under rubble in 0.7 m (CEG).
Etymology: The species is named after Emilio García, who provided the shell for study.

Description: Shell turbiniform, robust, spire formed by 4 ¼ rapidly expanding whorls. The protoconch has ¾ whorls, measures about 210 μm in diameter and has 4 spiral cords. Teleoconch formed by 3 ½ whorls, totally covered by thick spiral cords. In apertural view, two cords can be seen on the first whorl, 5 on the second and 17 on the last. On the last whorl, the 3rd, 5th and 6th cords are the most prominent, forming slight angles on the periphery

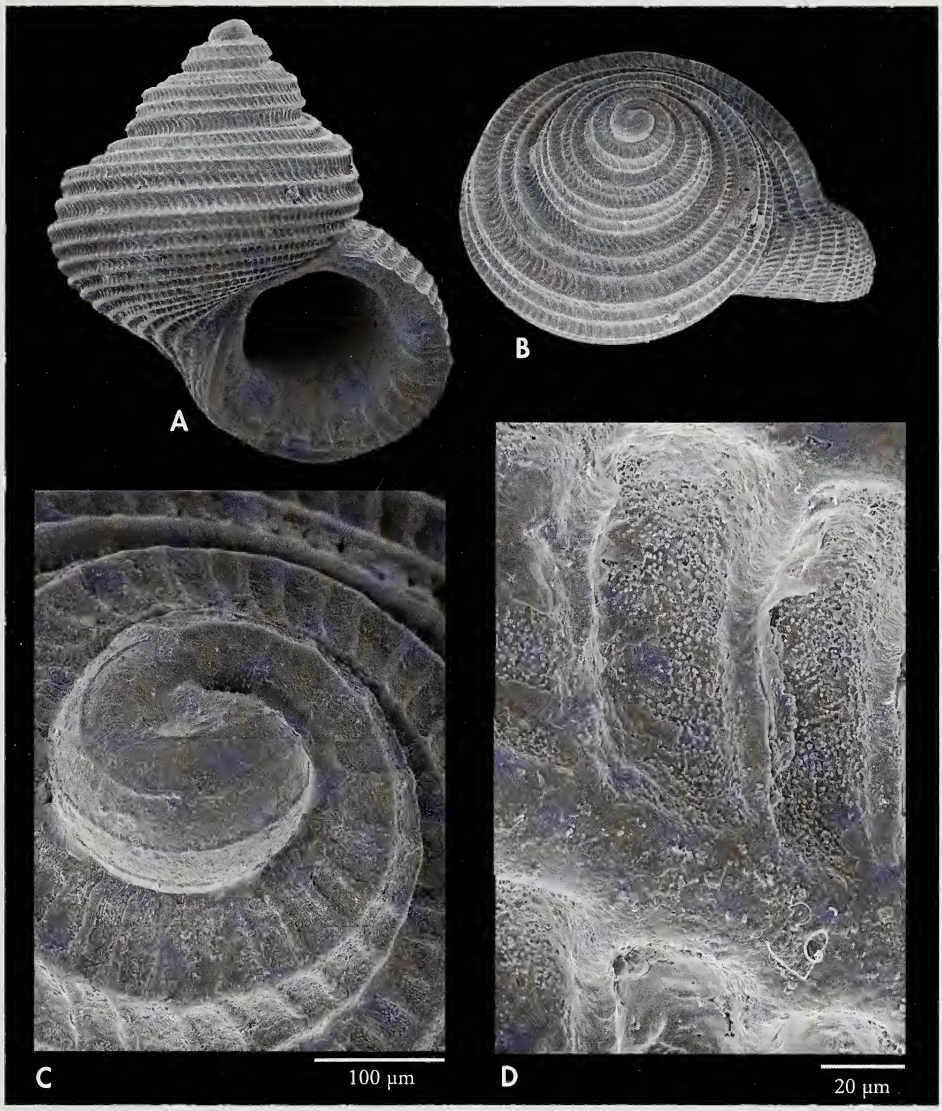

Figura 12. *Haplocochlias garciai* spec. nov. A, B: holotype, height 2.18 mm, S. Roatán Island, Honduras (USNM); C: protoconch; D: microsculpture from last whorl.
Figura 12. Haplocochlias garciai *spec. nov. A, B: holotipo, altura 2,18 mm, sur de la isla de Roatán, Honduras (USNM); C: protoconcha; D: microescultura de la última vuelta.*

of the shell. In the interspaces between the cords striae are distributed more or less regularly, forming rectangular cells whose surface is covered by microtubercles. Aperture circular, prosocline; outer lip very thick, widened frontally and strongly crenulated in its inner margin. The external thickening of the lip is very evident. Columella slightly sloping, triangular in shape, with a central groove, forming a rounded corner in its confluence with the outer lip. Umbilicus reduced to a narrow fissure, two fine cordlets penetrating inside.

Dimensions: The holotype measures 2.18 mm in height and 2.00 mm in diameter.

Habitat: Infralittoral species living under rubble in about ½ m deep.

Distribution: Only known from the type locality.

Remarks: *H. garciai* spec. nov. differs from the remaining species of the group by having the largest number of cordlets on the protoconch, a smaller number of cords in the teleoconch and by the shape of the lip.

From *H. swifti, it* can be distinguished by the lesser number of spiral cords and the denticles of the outer lip, which are wider. From *H. onaneyi* by the smaller diameter of the protoconch and the different shape of the denticles of the outer lip. From *H. minusdentatus* spec. nov. and *H. loperi* spec. nov. by the smaller diameter of the protoconch and the different shape of the denticles of the outer lip.

Haplocochlias williami Barros, Santos, Santos, Cabral & Acioli, 2002

Haplocochlias williami Barros, Santos, Santos, Cabral & Acioli, 2002. *Boletim Tecnico Cientifico do CEPENE* 10 (1): 45. [Type locality: Fernando de Noronha, Brazil].

Type material: Type material of *H. williami* in Museu de Malacologia da UFRPE (nº 7601.5). Not examined.
Other material examined: None.

Description: Original description of *H. williami* in Barros et al. (2002: 45): "*Concha pequena, turbinada, protoconcha formada por uma volta convexa e de aspecto liso, núcleo emerso, liso, posicionado no topo da espira. Espira mediana, correspondendo aproximadamente a 45% do CT da concha, ornada por várias cordas espirais fortes e dois ombros evidentes. Fenda umbilical parcialmente fechada. Linhas de crescimento evidentes nos espaços entre as cordas e as costelas, formando um fino retículo. Abertura circular, amplamente expandida com o hesteróstoma pouco refletido; lábio externo espesso marcado ventralmente e lateralmente por pregas macroscópicas. Região posterior do lábio externo afilada coincidindo com o início da forte região parietal, a qual é pouco extensa e levemente refletida sobre a parede umbilical. Base cônica não perfurada, delimitada interiormente por uma forte corda umbilical. Anfractos angulosos, sobretudo os espirais; a primeira volta da teleoconcha ornada apenas por dois ombros; espirais cruzados por linhas de crescimento microscópicas; linhas axiais microscópicas, que nesta região não estão restritas aos interespaços, se estendendo de sutura a sutura*".

Maximum reported size: 2.1 mm.

Habitat: In Brazil, *H. williami* was collected in sediments from grit bottom at 54 meters in depth.

Distribution: Brazil: Fernando de Noronha (Barros et al., 2002).

Remarks: Rosenberg (2013) stated that from the figures *H. onaneyi* seems to be a synonym of *H. williami*. On this synonymy see remarks under *H. onaneyi*. We regret not being able to present a figure of this species, from which only the holotype is known. The original figure is rather deficient; furthermore, the description is not very detailed. Under these conditions the identification of the species is very difficult. We have tried to borrow the holotype or find a similar shell, but our efforts were not successful.

Haplocochlias minusdentatus spec. nov. Rubio, Rolán & Redfern (Figure 13)

Haplocochlias sp. B. Redfern, 2001: 16, fig. 67; Redfern, 2013: 21, figs. 68A-B.

Type material: Holotype in FLMNH (464796) and 1 paratype in FLMNH (464796); other paratype in BMSM (52542).

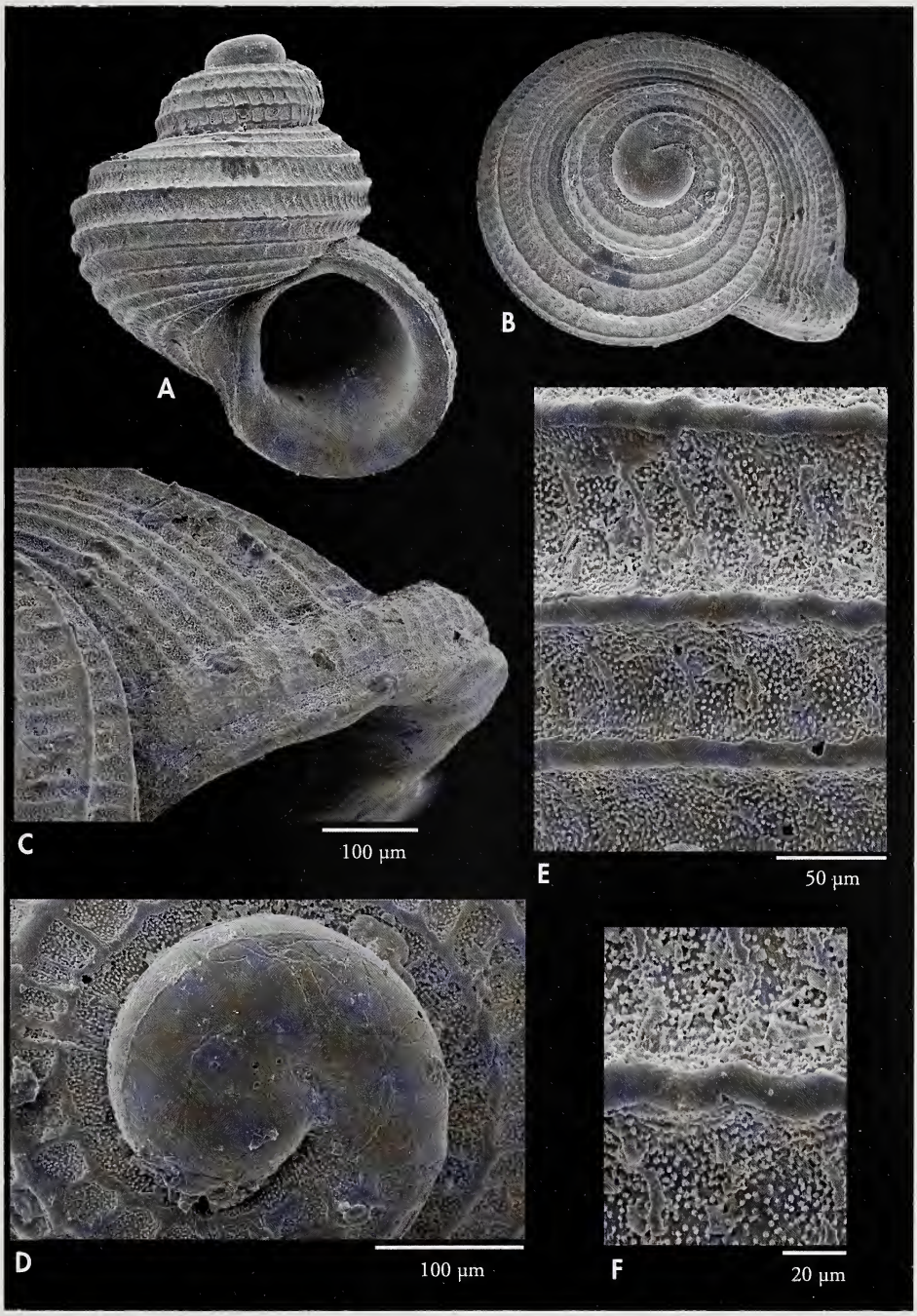

Figure 13. *Haplocochlias minusdentatus* spec. nov. A, B: holotype, 1.25 × 1.05 mm, Abaco Island, Bahamas (FLMNH); C: detail of the varicose outer lip; D: protoconch; E, F: microsculpture of the last whorl.

Figura 13. Haplocochlias minusdentatus *spec. nov. A, B: holotipo, 1,25 × 1,05 mm, isla de Abaco, Bahamas (FLMNH); C: detalle del labio externo varicoso; D: protoconcha; E, F: microescultura de la última vuelta.*

Other material examined: None.
Type locality: Abaco Island, Bahamas, 7 m.
Etymology: The name makes reference to its small size and the depressed denticles on the inner part of the outer lip.

Description: Shell very small, white in colour, with a spire formed by 3 1/4 rapidly expanding whorls. The protoconch has 3/4 whorls and measures about 250 μm in diameter, having 2-3 thin spiral cords. Teleoconch with 2 1/2 whorls, ornamented with strong spiral cords, prosocline axial striae in the spaces between the cords, and microtubercles. On the first whorl there are 4 spiral cords and 12-13 cords in the last one; the more pronounced of them are placed at the periphery, producing a slight angulation of the shell. The axial striae on the first whorls of the teleoconch form quadrangular spaces which become rectangular on the last one. Aperture rounded, prosocline, peristome continuous; outer lip and columella thick and reflected outwards; on the inner part of the outer lip faint, wide, and well-spaced crenulations can be seen; the columella is straight, basally wider forming an angular area, at the intersection of the umbilical cord and the outer lip. Umbilicus small, partially occluded by the reflection of the columella, inside there are 2-3 spiral threads. The outer margin of the outer lip forms a characteristic thickening similar to that of some species of the genus *Nassarius* (Nassariidae).

Dimensions: The holotype measures 1.25 mm in height and 1.05 mm in diameter.

Habitat: The photographed shell was collected from a coralline bottom at 7 m; the other two specimens were collected in a similar type of bottom between 6 m and 52 m.

Distribution: Only known from Abaco, Bahamas, its type locality.

Remarks: This is the smallest species of the group, 1.25 mm in height and 1.05 mm in diameter; in spite of this, it is the species with one of the largest protoconchs (250 μm in maximum diameter).

Haplocochlias minusdentatus spec. nov. can be distinguished from other species of the group (*H. swifti*, *H. onaneyi* and *H. garciai* spec. nov.) by its small size, fewer spiral whorls on the first and on the last whorl and a larger protoconch. From *H. loperi* it can be distinguished by having a greater number of spiral cords on the first whorl of the teleoconch.

Because of its size it might give the impression that it is a juvenile of another species, but the lip thickening and dilatation, and the weak crenulations on the interior of the outer umbilicus strongly suggest an adult stage. The other two specimens are of similar size and lip morphology, indicating that they are also adults.

Haplocochlias loperi spec. nov. Rubio, Rolán & Lee (Figure 14)

Type material: Holotype (FLMNH 457010) and two paratypes (FLMNH 457011), coll. M. Loper, November 2003.
Type locality: The G. Spot, French Cay, 18 m, Turks & Caicos Islands.
Etymology: Named for its collector, Dr. Michael Loper, a physician in Jacksonville, Florida.

Description: Shell very small, turbinate, with a robust appearance, as wide as high (H/D: 1.02), spire formed by 3 rapidly expanding whorls. The protoconch ¾ of whorl, measuring about 260 μm and with three thick spiral cords and a thickened lip varix. The teleoconch has 2 ¼ whorls ornamented by thick, prominent spiral cords, axial grooves and microtubercles. In apertural view there are 3 spiral cords on the first whorl and 11 cords on the last one. The cords are narrower than the interspaces. The

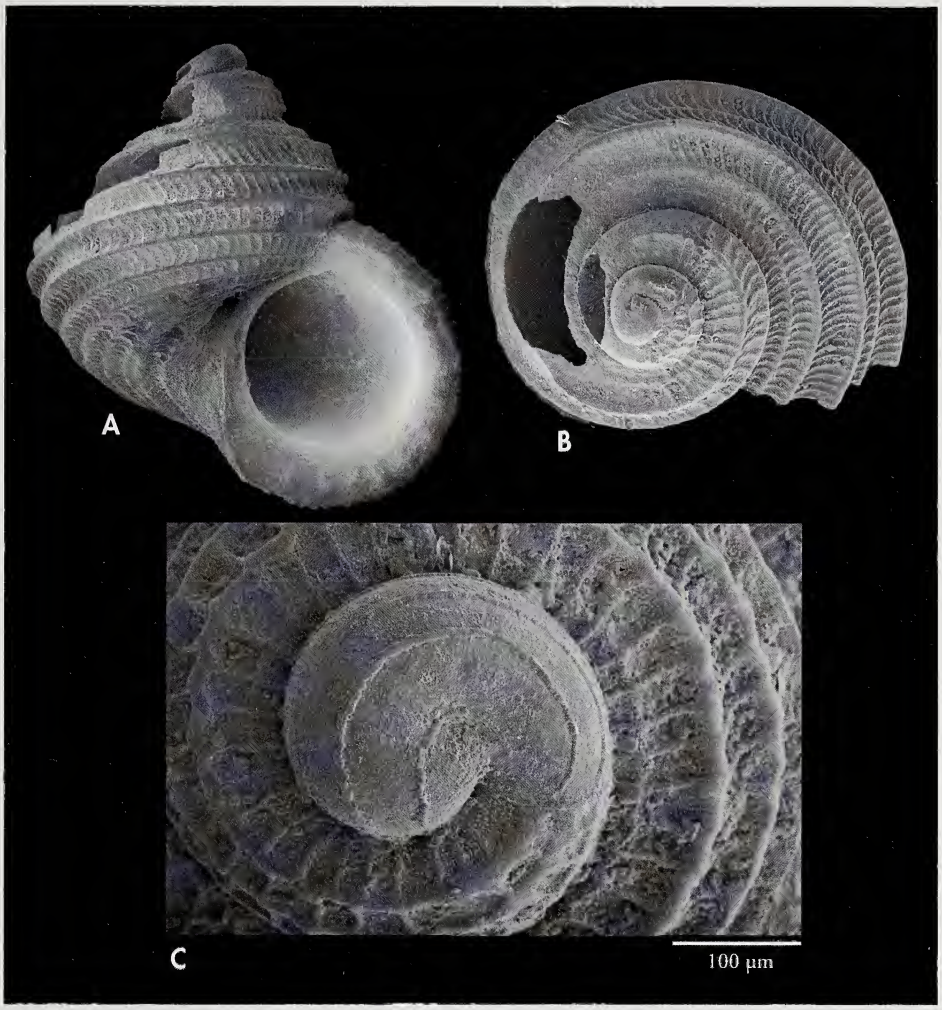

Figure 14. *Haplocochlias loperi* spec. nov. A: holotype, height 1.29 mm, Turks & Caicos (FLMNH); B: paratype (FLMNH); C: protoconch of the other paratype.
Figura 14. Haplocochlias loperi *spec. nov. A: holotipo, altura 1,29 mm, Turks & Caicos (FLMNH); B: paratipo (FLMNH); C: protoconcha del otro paratipo.*

axial striae are strong, somewhat prosocline, are regularly spaced and occupy all of the space between cords, which is slightly concave; at the crossing point with the cords small irregular nodules form as rectangular cells completely covered by microtubercles. Aperture rounded, prosocline, peristome continuous; outer lip thickened and frontally expanded, showing weak, long, wide denticles on its inner basal aspect; parietal area covered by a thin callous coat; columella straight, very wide at its base, scarcely reflected. Umbilicus small, partially covered by the parietal reflection, on its inner wall there are thin growth lines and two spiral cordlets.

Dimensions: The holotype is 1.29 mm in height and 1.26 mm in maximum diameter.

Habitat: Unknown.

Distribution: Known only from the type locality.

Haplocochlias loperi spec. nov. differs from its congeners, *H. garciai* spec. nov., *H. onaneyi* and *H. swifti*, by its smaller size, the size of the protoconch (260 μm, one of the larger in the genus), by the small number of spiral cords, the prominent form of these and the concavity of the spaces between cords. The closest species (due to its size) is *H. minusdentatus*, which differs in the teleoconch spiral sculpture, having 3 cords on the first whorl instead of four and by the thickness of the cords of the protoconch. From *H. bieleri* spec. nov. it differs in the small number of spiral cords and the different shape of the denticulations inside the outer lip.

Haplocochlias bieleri spec. nov. (Figures 15, 16)

Type material: Holotype (Figs. 15A-B) in FMNH (333880). Paratypes: 6 in FMNH (333878, 333879, 288220, 333896) from close areas in Florida, Monroe County, USA).
Type locality: Florida, Monroe County, Sta. FK-202, Molasses Reef, Upper Florida Keys, USA, 25° 00′ 33″N, 080° 22′ 35″W, 7 m deep.
Etymology: Named for its collector, Dr. Rüdiger Bieler, Curator, Division of Invertebrates, Field Museum, Chicago.

Description: Shell very small, turbiniform, strong and robust, higher than wide (H/D: 1.20) with spire formed by 3 ½ quickly increasing whorls. The protoconch has ¾ whorl, measuring 230 μm and on it three strong cords can be seen as well as the varix of a thickened lip. The teleoconch has 2 ¾ whorls and its ornamentation is formed by strong spiral cords, some very prominent, axial striae and microtubercles. In apertural view 2 spiral cords can be seen on the first whorl, 3 cords on the second and 25 cords on the last one; in each whorl there are two very prominent cords which make the profile angulate. The interspaces between cords are of similar size in the sutural and peripheral areas, but in the base they become narrower and closer set. If the holotype is observed in apical view it can be seen that in the last ½ whorl, between the spiral cords, new cordlets are formed, which increase in the proximity of the external lip, of equal size and also with spaces between cords. The axial striae are somewhat prosocline, on the first whorl they are more separate forming quadrangular spaces totally covered by microtubercles; on the subsequent whorls the striae are more numerous and closer. Aperture rounded, prosocline, peristome continuous; external lip very wide and expanded frontally, and inside elongated and irregular denticles can be seen, which are extended from the external margin towards the inside, grouped by two. The columella is almost straight and is widened towards the base, it is very wide and is reflected towards the umbilicus, which is occluded almost entirely; the parietal area is covered by a strong coat.

Dimensions: the holotype is 1.56 mm in height and 1.30 mm in maximum diameter (H/D: 1.20).

Habitat: The type material was collected in a reef with sandy patches, at 7 metres.

Distribution: Known only from the type locality.

Remarks: The main morphological character which differentiates *H. bieleri* from the other species of the genus, is the presence of the two spiral cords per whorl which are projected as carinae over the others, form an angle on the shell and give it a characteristic profile. Other differential characters are the shape of the shell, the number of spiral cords and their greater concentration in the basal area, the shape of the external lip, columella and umbilicus, practical occluded by the reflection of the columella. If we observe a specimen of *H. bieleri* not totally adult (Figs. 15D), we can see that the two peripheral carinae per whorl are invariable; however, the

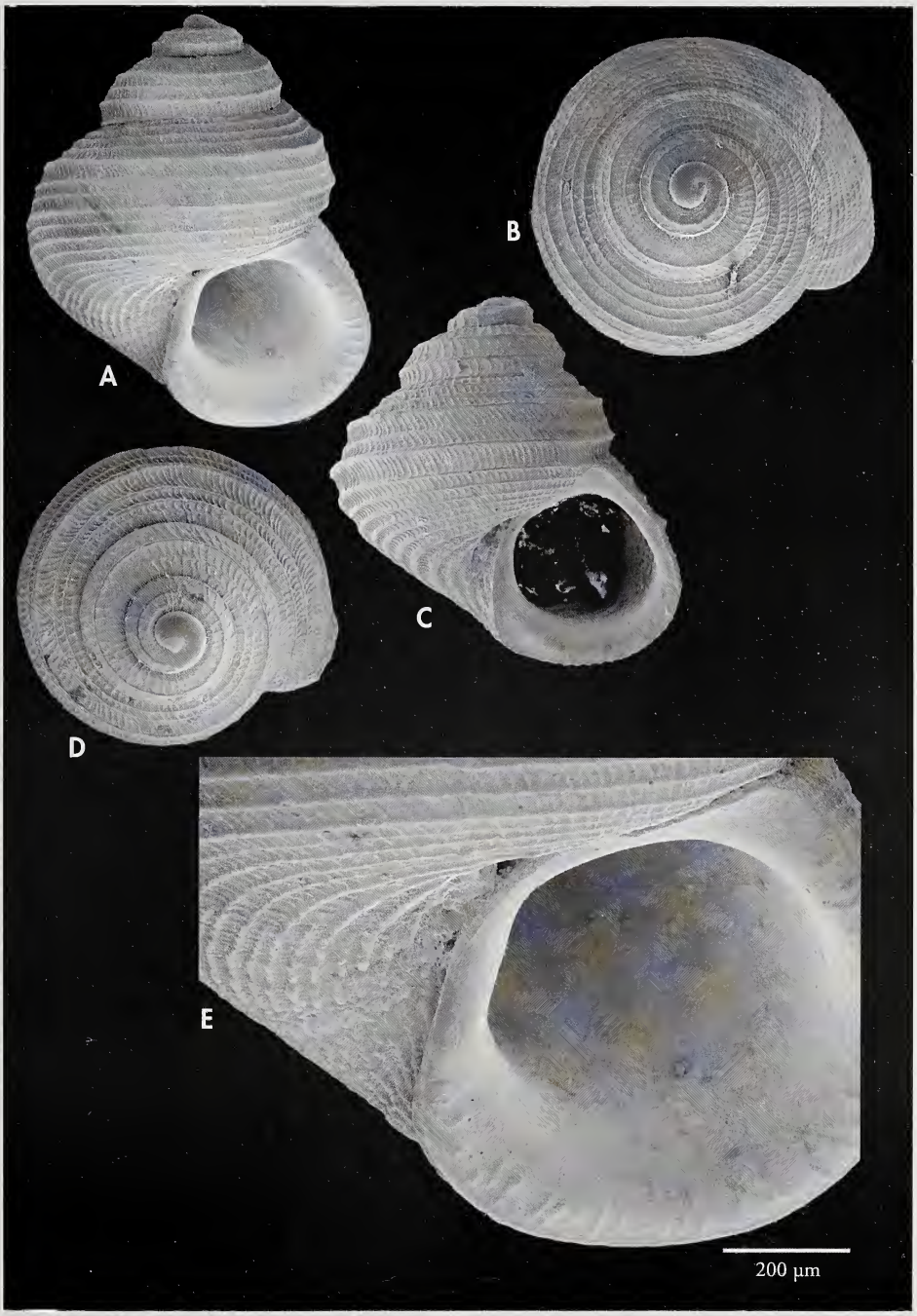

Figure 15. *Haplocochlias bieleri* spec. nov. A, B: holotype, 1.56 × 1.3 mm, Florida, USA (FMNH); C, D: paratype, 1.2 × 1.25 mm; E: detail of the aperture and columellar area of the holotype (FMNH).

Figura 15. Haplocochlias bieleri *spec. nov. A, B: holotipo, 1,56 × 1,3 mm Florida, EE.UU. (FMNH); C, D: paratipo, 1,2 × 1,25 mm; E: detalle de la abertura y del área columelar del holotipo (FMNH).*

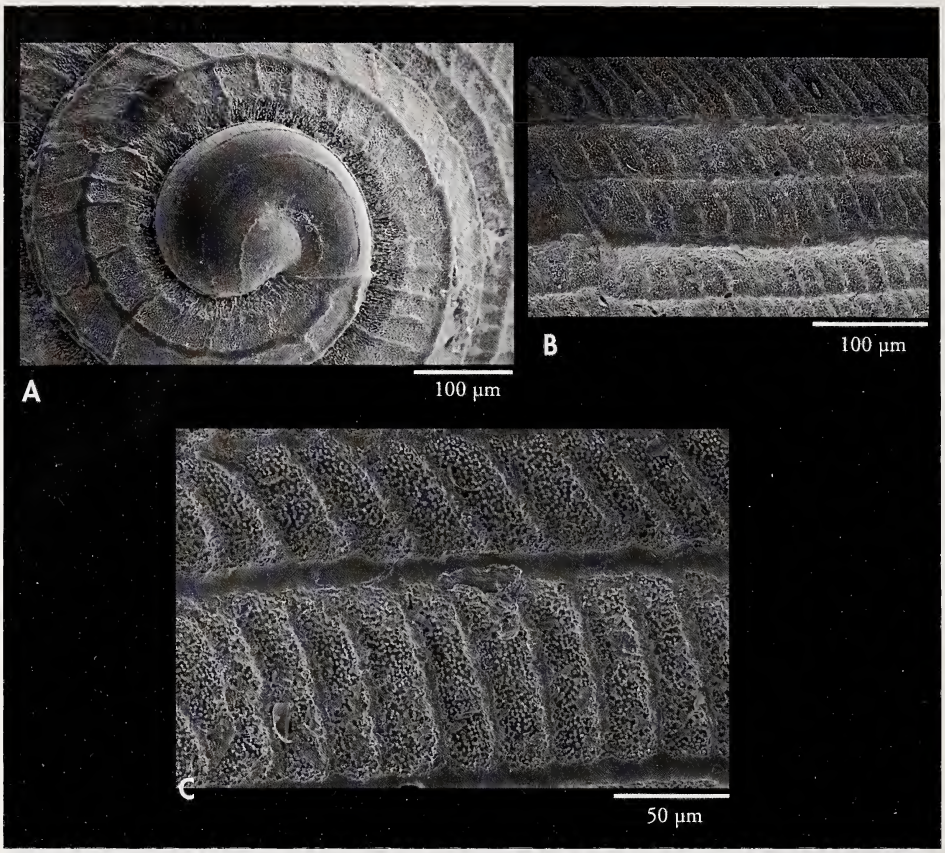

Figure 16. *Haplocochlias bieleri* spec. nov. A: protoconch of a paratype; B, C: microsculpture of the last whorl.

Figura 16. Haplocochlias bieleri *spec. nov. A: protoconcha de un paratipo; B, C: microescultura de la última vuelta.*

number of spiral cords decrease drastically (15 on the last whorl), the external lip is not totally expanded, the denticles inside the external lip can be seen clearly and the columella does not occlude the umbilicus which is shown as a small fissure. These morphological differences between the adult and the non-adult specimens could incorrectly lead to the description of new species. The closer species by its general shape and dimensions is *H. minusdentata*, from which it can be distinguished by the larger number of the spiral cords and their shape, by the shape and number of the denticles of the external lip and by the umbilicus almost occluded. From the general shape and the denticulation of the external lip, the closest species is *H. onaneyi*, from which it can be distinguished by its smaller size, larger number of spiral cords, two peripheral carinae by whorl and the umbilicus almost totally closed by the reflection of the columella.

H. bieleri spec. nov. differs from *H. garciai* spec. nov. and *H. swifti* mainly by its small size (<1.6 mm), from *H. williami* by the larger number of spiral cords, and from *H. loperi* it is distinguished furthermore by its umbilicus being practically closed, by the different shape of the labial denticles and the larger number of spiral cords.

ortizi group

Remarks: The main characteristics of the species which form this group is having the shape of a spinning top, the very numerous axial striae, and the straight columella widened at its base, which angles the aperture at its intersection with the outer lip and the umbilical cord.

Haplocochlias ortizi Espinosa, Ortea & Fernández-Garcés, 2005 (Figures 17, 18)

Haplocochlias ortizi Espinosa, Ortea & Fernández-Garcés, 2005b. *Avicennia* 17: 73, figs. 1D-F. [Type locality: Rancho Luna Beach, Cienfuegos, Cuba, 54 m].

Type material: Holotype in IES, CITMA, Havana, Cuba. Paratypes in MNCN, Madrid; MNH of Santa Cruz de Tenerife and MHN "Carlos de la Torre" de Holguín, Cuba.
Material examined: Cuba: 3 s, Rancho Luna Beach, 10-20 m; 3 s, Rancho Luna Beach, 30 m; 15 s, Rancho Luna Beach, coralline sediments, 40 m; 4 s, Rancho Luna Beach, 45 m; 2 s, Punta de Tamarindo, 56 m; 2 s, Faro Colorados, 36 m; 1 s, Havana, 15 m.

Description: Original description in ESPINOSA *ET AL.* (2005): *Concha de tamaño pequeño, turbiniforme, de color blanco leche y escultura espiral muy marcada. Protoconcha de 0.5 vueltas lisas y brillantes, sin escultura notable. Teleoconcha de unas 3,3 a 3,5 vueltas, esculturadas con fuertes costillas espirales, entre las que hay líneas axiales de crecimiento, presentes desde el comienzo de la teleoconcha hasta el final de la última vuelta. Ombligo estrecho. La abertura es circular, reforzada por un fuerte peristoma engrosado en su cara externa, frontalmente aplanado y sin escultura, con una prolongación notable hacia la base de la concha*". We add: Protoconch ¾ whorl, about 230 μm in diameter, smooth surface with 3 spiral cordlets and a thick lip varix. The teleoconch has 3 ¾ whorls. Sculpture of thick spiral cords, and the interspaces between cords covered by fine closely-packed axial prosocline grooves. On the first whorl there are 2 spiral cords, 3 in the second, and 15-20 on the last one; of the latter, the first five are distributed between the sutures and, are more prominent at the periphery and their interspaces are unequal; the cords which are distributed towards the base are sized more regularly, as are their interspaces. After the first whorl of the teleoconch numerous axial striae appear between cords, replacing the cells and the microtubercles. On the last half whorl, between the spiral cords other finer ones appear, giving the appearance that the cords are double.

The aperture is rounded; at the confluence of the columella and the outer lip, an angulation is formed, extending outwards and as well as partially occluding the umbilicus, which is narrow, delimited by a thick cord; inside there are 2-3 thin cordlets.

Maximum reported size: 3 mm. The shell figured measures 2.7 mm in height.

Habitat: The type material was found in sediments from coralline sandy bottom at 54 m. The other material examined is from sediments collected at 40 m.

Distribution: Only known from Rancho Luna Beach, Cienfuegos, Cuba, the type locality.

Remarks: ESPINOSA *ET AL.* (2005: 72) reported: "Haplocochlias ortizi, *especie nueva, difiere de* H. onaneyi (= williami) *por ser de tamaño algo mayor, carecer de escultura espiral en la protoconcha y por tener las líneas axiales intercostales de crecimiento más finas. De* H. swifti *se diferencia por ser de tamaño menor, tener ombligo y carecer de escultura en la cara frontal del peristoma.* H. moolenbeeki *es una especie de tamaño mayor, ampliamente umbilicada y de peristoma poco engrosado*".

Likewise, in the original description the authors mention that the protoconch

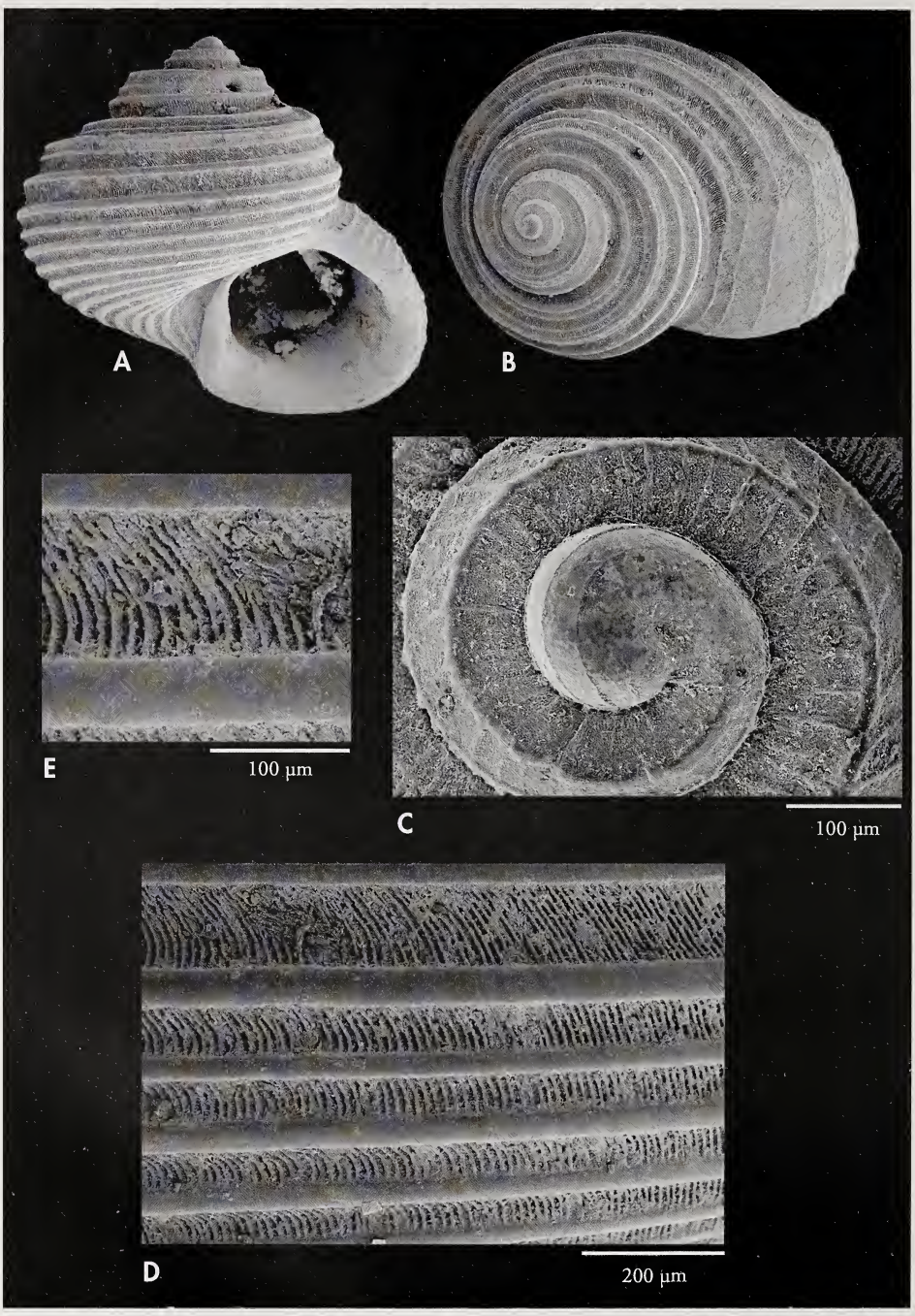

Figure 17. *Haplocochlias ortizi* Espinosa, Ortea & Fernández-Garcés, 2005. A, B: adult shell, 2.1 × 2.7 mm, Rancho Luna Beach, Cienfuegos, Cuba (MHNS); C: protoconch, same shell as B; D, E: microsculpture and detail of the last whorl.

Figura 17. Haplocochlias ortizi *Espinosa, Ortea & Fernández-Garcés, 2005. A, B: concha adulta, 2,1 × 2,7 mm, Playa Rancho Luna, Cienfuegos, Cuba (MHNS); C: protoconcha, misma concha que B; D, E: microescultura y detalle de la última vuelta.*

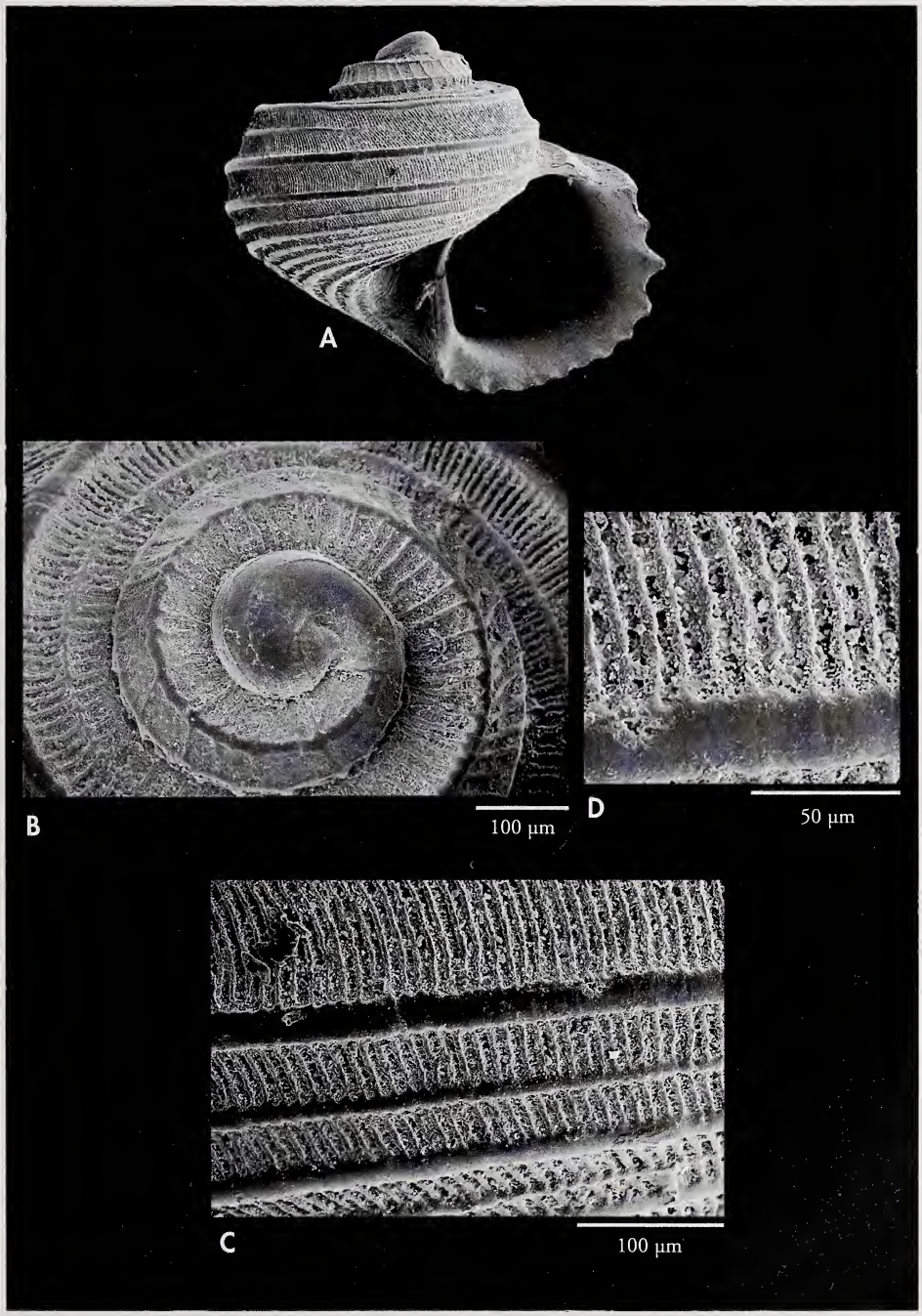

Figure 18. *Haplocochlias ortizi* Espinosa, Ortea & Fernández-Garcés, 2005. A: juvenile shell, diameter 1.5 mm, Rancho Luna Beach, Cienfuegos, Cuba (MHNS); B: protoconch of the same shell; C, D: microsculpture of the last whorl.

Figura 18. Haplocochlias ortizi *Espinosa, Ortea & Fernández-Garcés, 2005. A: concha juvenil, diámetro 1,5 mm, Playa Rancho Luna, Cienfuegos, Cuba (MHNS); B: protoconcha de la misma concha; C, D: microescultura de la última vuelta.*

is smooth, but photographs of shells from the type locality (Fig. 17C) show that they have some oblique cords.

The differential characters of this species are: the axial sculpture with very dense and close vertical lamellae in the interspaces between the cords, the non-crenulated labial thickening and the columella being reflected outward along its entire length.

Haplocochlias densistriatus spec. nov. Rubio, Rolán & Lee (Figure 19)

Type material: Holotype in FLMNH (457015). Paratypes in FLMNH (457014, 1 s and 457016, 1 s) and in CHL (1 s).
Other material examined: Bahamas Islands: 3 s, off W side Cape Eleuthera, Eleuthera, 29 m, base of reef wall (CHL); 3 s, Long Cay Mooring, Long Cay, 23 m, hole in reef (CHL).
Type locality: Cape Eleuthera, Eleuthera, Bahamas Islands, 29 m.
Etymology: The specific name refers to the density of the axial striae.

Description: Shell small, turbiniform, with a conspicuous spire formed by slightly more than 4 rapidly expanding whorls. The protoconch 3/4 whorl, measuring 220 μm and having 3 very distinct spiral cordlets. The teleoconch consists of 3 1/2 whorls, ornamented with spiral cords and axial grooves, and microturbercles in their interspaces. The cords are narrower than their interspaces and number 2 on the first and second whorls and 9 on the last. On the first whorl of the teleoconch, the axial striae are more separated, forming quadrangular spaces; on the second whorl the axial grooves become more numerous, getting progressively closer together to form fine elongate lamellae which imparts a fine and elegant appearance to the teleoconch. Umbilicus broad and deep, delimited by a thick spiral cord, and towards its inner part the axial lamellae penetrate, but no spiral cordlets are observed. Aperture rounded, peristome continuous; outer lip very thick and widened frontally, without crenulations inside; parietal area covered by a thin callous coat; columella almost straight, widened at its base and reflected outward, forming a widening at the intersection with the umbilical cord and the outer lip.

Dimensions: holotype 1.97 mm in height and 2.19 mm in diameter. The largest of the examined specimens measured 2.15 mm in height and 2.37 mm in diameter.

Habitat: Between 25 and 30 m, at the base of the reef.

Distribution: Only known from Cape Eleuthera and Long Cay Mooring, Bahamas Islands.

Remarks: *Haplocochlias densistriatus* spec. nov. can be distinguished from *H. ortizi* because the latter has fewer spiral cords, the interspaces between the cords are larger, the axial sculpture is formed by a larger number of elongate lamellae, and it has a wider umbilicus.

cubensis group

Remarks: The main characteristic of this group of species is that the adult shell develops an outer lip which is frontally extended but not very thick.

Haplocochlias cubensis Espinosa, Ortea & Fernández-Garcés, 2007 (Figure 20)

Haplocochlias cubensis Espinosa, Ortea & Fernández-Garcés in Espinosa, Ortea, Fernández-Garcés & Moro, 2007. *Avicennia*, 19: 64-65, fig. 4. [Type locality: diving site Yemayá, María la Gorda, Guanahacabibes, Pinar del Río, Cuba, 30-40 m].

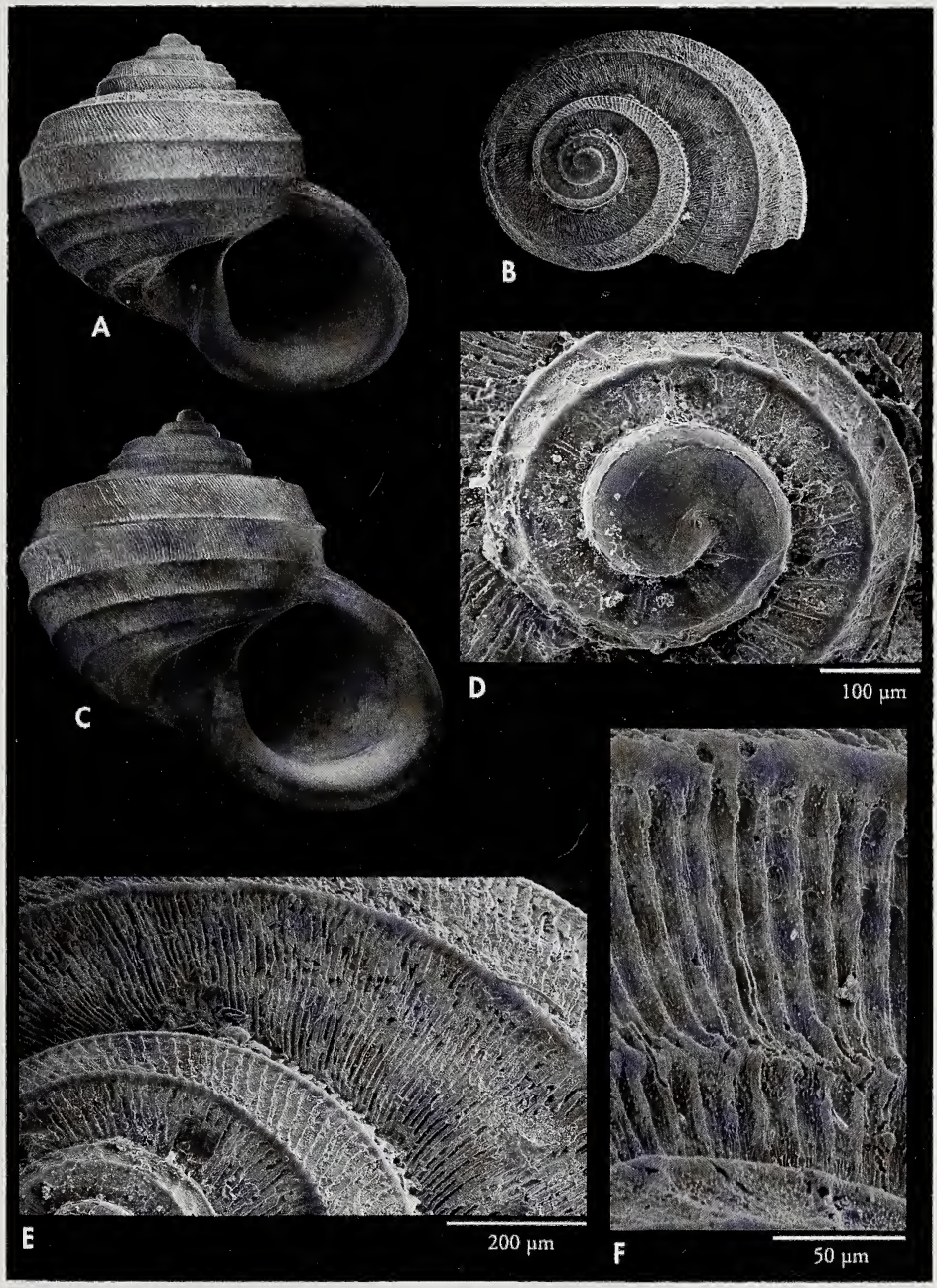

Figure 19. *Haplocochlias densistriatus* spec. nov. A: holotype, diameter 2.19 mm, Cape Eleuthera, Eleuthera, Bahamas (FLMNH); B: paratype, diameter 1.6 mm, same locality (FLMNH); C: paratype, diameter 2.35 mm, Long Cay Mooring, Long Cay, Bahamas (CHL); D: protoconch, same shell as B; E, F: microsculpture and detail of the last whorl.

Figura 19. Haplocochlias densistriatus *spec. nov. A: holotipo, diámetro 2,19 mm, Cabo Eleuthera, Eleuthera, Bahamas (FLMNH); B: paratipo, diámetro 1,6 mm, misma localidad (FLMNH); C: paratipo, diámetro 2.35 mm, Long Cay Mooring, Long Cay, Bahamas (CHL); D: protoconcha, misma concha que B; E, F: microescultura y detalle de la última vuelta.*

Type material: Holotype in the IES, Havana, Cuba. Two paratypes in the Museo de Ciencias Naturales de Tenerife, Canary Islands. Paratype in the collection of the second author (RFG), examined.
Other material examined: 5 s, María la Gorda, Guanahacabibes, Pinar del Río, Cuba, 30-40 m (MHNS).

Description: Original description in Espinosa, Ortea, Fernández-Garcés & Moro (2007): "*Concha pequeña, turbiniforme, de color blanco hialino, con 4 ½ vueltas de las cuales la primera, decorada por dos hilos espirales, es de protoconcha. La teleoconcha está formada por 3 ½ vueltas, la primera decorada por tres cordones espirales entre los que hay laminillas axiales prosoclinas de crecimiento, regularmente separadas; hacia el final de la segunda vuelta hay unos 8 cordones espirales, con semejantes costillitas intercaladas; hacia el final de la penúltima vuelta hay unos 22 cordones. Al final de la última vuelta hay 72 cordones espirales, contando los 5 en el interior del ombligo. Abertura circular, engrosada solamente en la base, donde hay una prolongación por efecto de la terminación del cordón que limita el ombligo. Peristoma poco engrosado, crenulado por la terminación de los finos cordones espirales*".

We add: The protoconch has ¾ whorl, measures 240 μm in maximum diameter, has a slightly granular surface and has 3 spiral cordlets. A thick varix marks the transition to the teleoconch, which has 3 ½ spiral whorls. The 2 ¼ first whorls display prosocline axial striae between the spiral cords, forming cells that are covered by microtubercles. On the 1 ¼ remaining whorls the axial striae disappear, while the spiral cords are covered by microtubercles. The last whorl presents 70-75 crowded spiral cordlets, including those inside the umbilicus; which has a rounded periphery. The aperture is nearly circular; the columella is slightly reflected outwards and the outer lip is crenulated due to the presence of the spiral cords. The umbilicus is narrow, partially occluded by the reflection of the columella; no periumbilical cord is observed.

Dimensions: The figured specimen is 2.65 mm in diameter and 2.51 mm in height (H/D: 0.95). Maximum reported size: 3 mm.

Habitat: Collected in coralline bottoms, 30-40 m (Espinosa, Ortea, Fernández-Garcés & Moro, 2007).

Distribution: Only known from María la Gorda, Guanahacabibes, Pinar del Río, Cuba, its type locality.

Remarks: Espinosa *et al.* (2007) in relation to the protoconch mention: "... *con 4 ½ vueltas de las cuales la primera, decorada por 2 hilos espirales, es de protoconcha*". However, as can be seen (Fig. 20C), the protoconch has 3 spiral cordlets, like other species of the genus.

Haplocochlias cubensis is primarily characterized by the great number of spiral cords on the last whorl, about 72 (including 5 located in the inner part of the umbilicus), with a laminar appearance, produced by deep grooves between them, the lack of axial sculpture, and the presence of microtubercles on the cords. It differs from the remaining species in the genus by its rounded periphery, by the great number of spiral cords on the last whorl, by the absence of keels, the absence of axial grooves in the final ¼ whorl and its crenulated, not thickened, lip.

Haplocochlias arrondoi spec. nov. (Figures 1, 21, 22)

Type material: Holotype (Fig. 21A) deposited in MNCN (15.05/60043). Paratypes in the following: MNHN (IM -2012-2530, 1 s, Fig. 21B), MHNS (100577, 1 s, Fig. 21C), MCZ (377778, 1 s, Fig. 21D, 22A), FLMNH (457013, 1 s, Fig. 21E) all from Rancho Luna Beach, Cuba; IES (1 s, Fig. 21F) from Faro de los Colorados, Cienfuegos, Cuba; collection of E. Arrondo (1 s).
Other material examined: Cuba: 8 s, Cienfuegos Bay, 35 m (MHNS); 8 s, Rancho Luna Beach, 10-20 m (MHNS); 6 s, Rancho Luna Beach, 30 m (MHNS); 8 s, Rancho Luna Beach, 35 m (MHNS); 4 s,

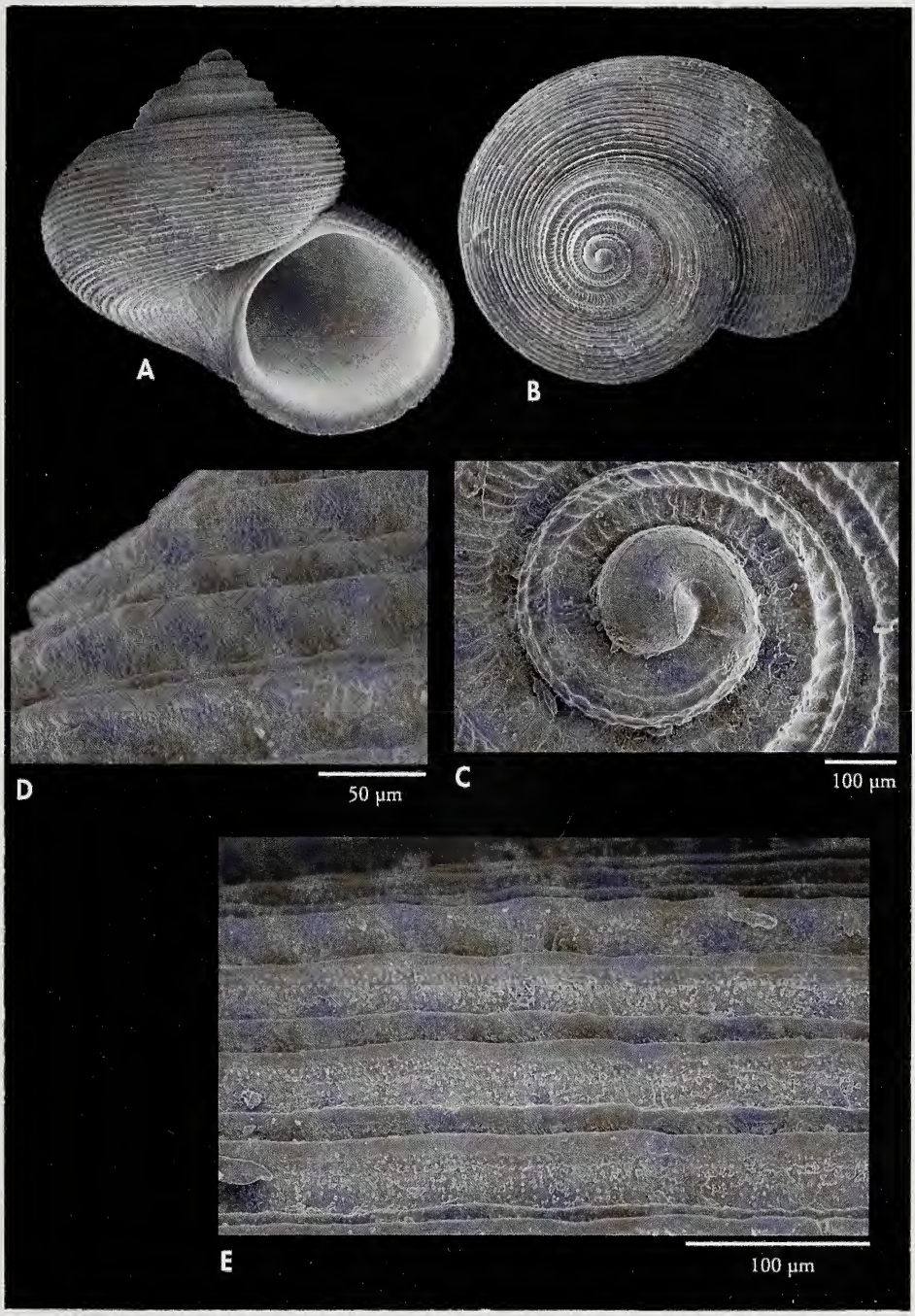

Figure 20. *Haplocochlias cubensis* Espinosa, Ortea & Fernández-Garcés, 2007. A, B: shell, diameter 2.65 mm, María la Gorda, Guanahacabibes, Cuba (MHNS); C: protoconch of the same shell; D, E: microsculpture of the last whorl.

Figura 20. Haplocochlias cubensis *Espinosa, Ortea & Fernández-Garcés, 2007. A, B: concha, diámetro 2,65 mm, María la Gorda, Guanahacabibes, Cuba (MHNS); C: protoconcha de la misma concha; D, E: microescultura de la última vuelta.*

Rancho Luna Beach, 40 m (MHNS); 8 s, Rancho Luna Beach, 45 m (MHNS); 5 s, Faro Colorados, 35 m (MHNS); 4 s, Faro Colorados, 56 m (MHNS); 2 s, Punta Tamarindo, 56 m (MHNS); 1 s, Los Laberintos, 35 m (MHNS).

Type locality: Rancho Luna Beach, Cienfuegos, Cuba, 30-40 m.

Etymology: The name is after the malacologist Ernesto Arrondo Odriozola, from Donostia, Spain.

Description: Shell very small, turbiniform, as high as wide (H/D: 1), spire formed by 3 ½ whorls separated by a wide and deep suture. The protoconch has ¾ whorls, measuring about 240 μm in diameter, smooth except for 3 spiral cordlets which run through it. Teleoconch formed by 3 ¼ whorls, rounded, slightly angled on the periphery in its dorsal area by three spiral cords somewhat higher than others. Ornamentation consisting of spiral cords, fine axial grooves in the spaces between them and microtubercles distributed between the axial striae. Cords are fairly uniform in size as are their interspaces, and the axial striae are regularly distributed throughout the teleoconch. On the first whorl there are 3-4 spiral cords; 8 in the second, and 32 on the last; of these the 2nd, but especially the 5th and 8th are the highest and stand out on the periphery as small keels. On the last half-whorl, the suture becomes broad and deep, axial striae disappear, and fine spiral cordlets appear in the interspaces in the area near the outer lip so that one loses count of the total number of cords. Aperture rounded, peristome continuous, barely attached; both the outer and inner lips appear frontally expanded without denticulation or apparent crenulations; just at the point of union between the inner lip, the outer lip and the umbilical cord an expansion and a small angulation are formed. Base slightly concave. Umbilicus narrow, deep, not modified or occluded; it is delimited by a strong spiral cord; on its inner part 2-3 fine cordlets can be observed.

Operculum multispiral with a central nucleus.

Radula formula N.5.1.5.N. The rachidian tooth is broad (not as much as *H. cyclophoreus*, type species of the genus). The laterals are well developed and are similar in size and shape; they present a characteristic bend in the shaft and cusps with finely serrated margins (outer and inner). There is a latero-marginal plate fused to the first marginal tooth shaft. The marginal teeth are the same shape, with long, narrow and strongly overhanging cusps, strongly curved outward.

Dimensions: Holotype: 2.13 mm in height and 2.17 mm in diameter (H/D= 0.98); paratype (MHNS): 1.66 mm in height and 1.66 mm in diameter (H/D= 1.00); Faro de los Colorados: (paratype in IES) 2.41 mm in diameter and 2.2 mm in height (H/D: 0.91); the largest shell (paratype in MCZ) examined measured 1.75 mm in diameter.

Habitat: Frequently found in sediments taken from coralline sand bottom between 15 and 50 m in depth.

Distribution: Rancho Luna Beach and Faro los Colorados, Cienfuegos, Cuba.

Remarks: We have seen a remarkable morphological difference between fully adult individuals which have developed the frontally expanded lip and individuals that being slightly sub-adult still have not developed it, as can be seen in the photographed samples from Rancho Luna (Figs. 21C-E): the outer lip first has a sharp border, slightly-denticulate by the presence of spiral cords; parietal area of the inner lip without callus, reduced to a thin lamella; the columella is curved at the beginning, then becomes deflected, widens towards its base and forms an angle at the point of junction with the umbilical cord and the outer lip.

Haplocochlias arrondoi spec. nov. may be distinguished from the other species with a spirally-corded protoconch by the presence on the teleoconch of 2 more elevated spiral cords forming a sort of keel which angulates the shell giving it a characteristic profile, by the number of cords on the last whorl, and by the development in fully adult shells of a frontally expanded lip, which is neither denticulate nor crenulated. *Haplocochlias cubensis* has a greater number of spiral cords on the last teleoconch whorls and

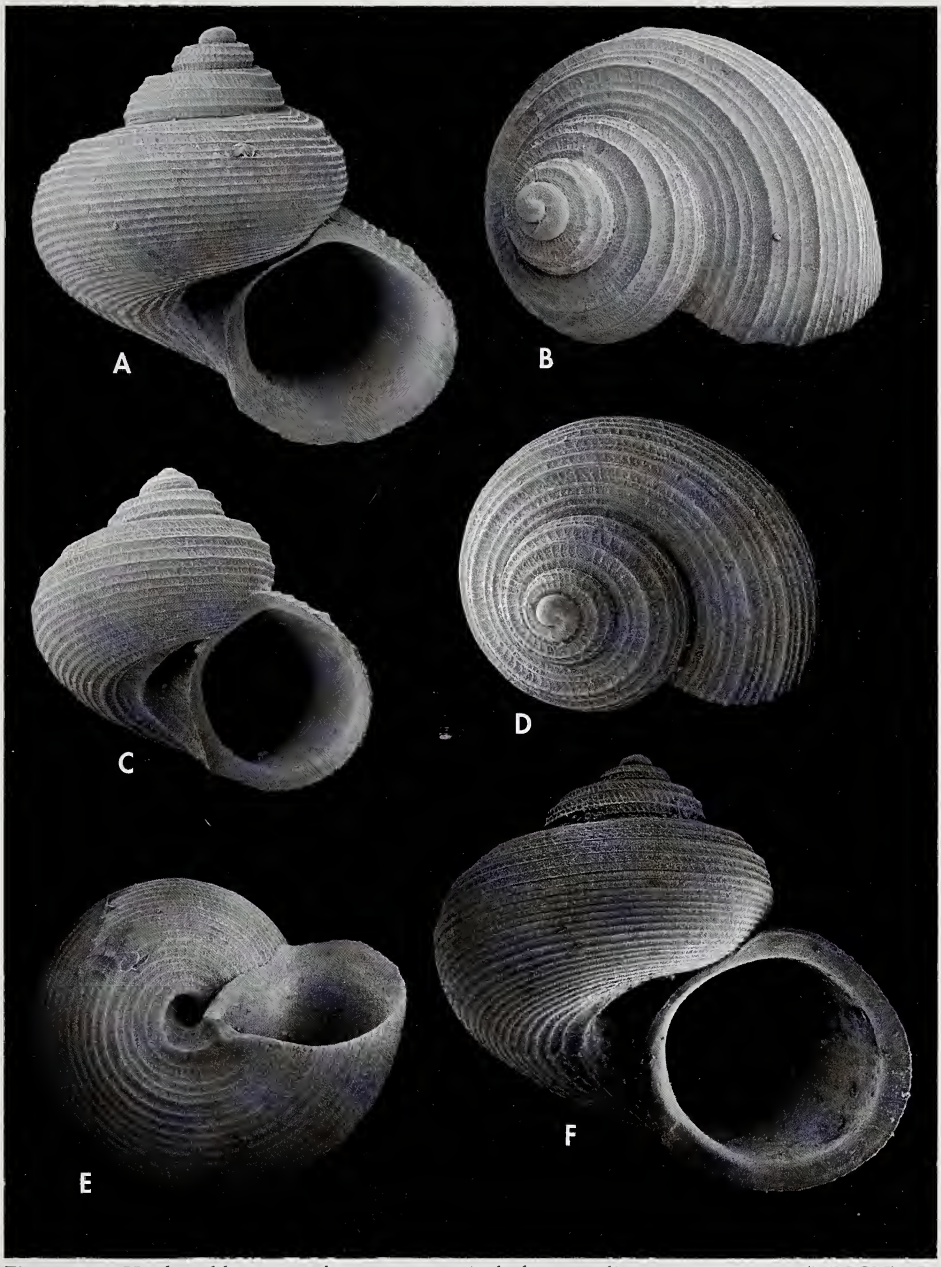

Figure 21. *Haplocochlias arrondoi* spec. nov. A: holotype, diameter 2.17 mm (MNCN); B: paratype, diameter 1.9 mm (MNHN); C: paratype, diameter 1.66 mm (MHNS); D: paratype, diameter 1.75 mm (MCZ); E: paratype, diameter 2.1 mm (FMNH), all from Rancho Luna Beach, Cienfuegos, Cuba; F: paratype, diameter 2.41 mm (IES), Faro Colorados, Cienfuegos, Cuba.

Figura 21. Haplocochlias arrondoi *spec. nov. A: holotipo, diámetro 2,17 mm (MNCN); B: paratipo, diámetro 1,9 mm (MNHN); C: paratipo, diámetro 1,66 mm (MHNS); D: paratipo, diámetro 1,75 mm (MCZ); E: paratipo, diámetro 2,1 mm (FMNH), todos de Playa Rancho Luna, Cienfuegos, Cuba; F: paratipo, diámetro 2,41 mm (IES), Faro Colorados, Cienfuegos, Cuba.*

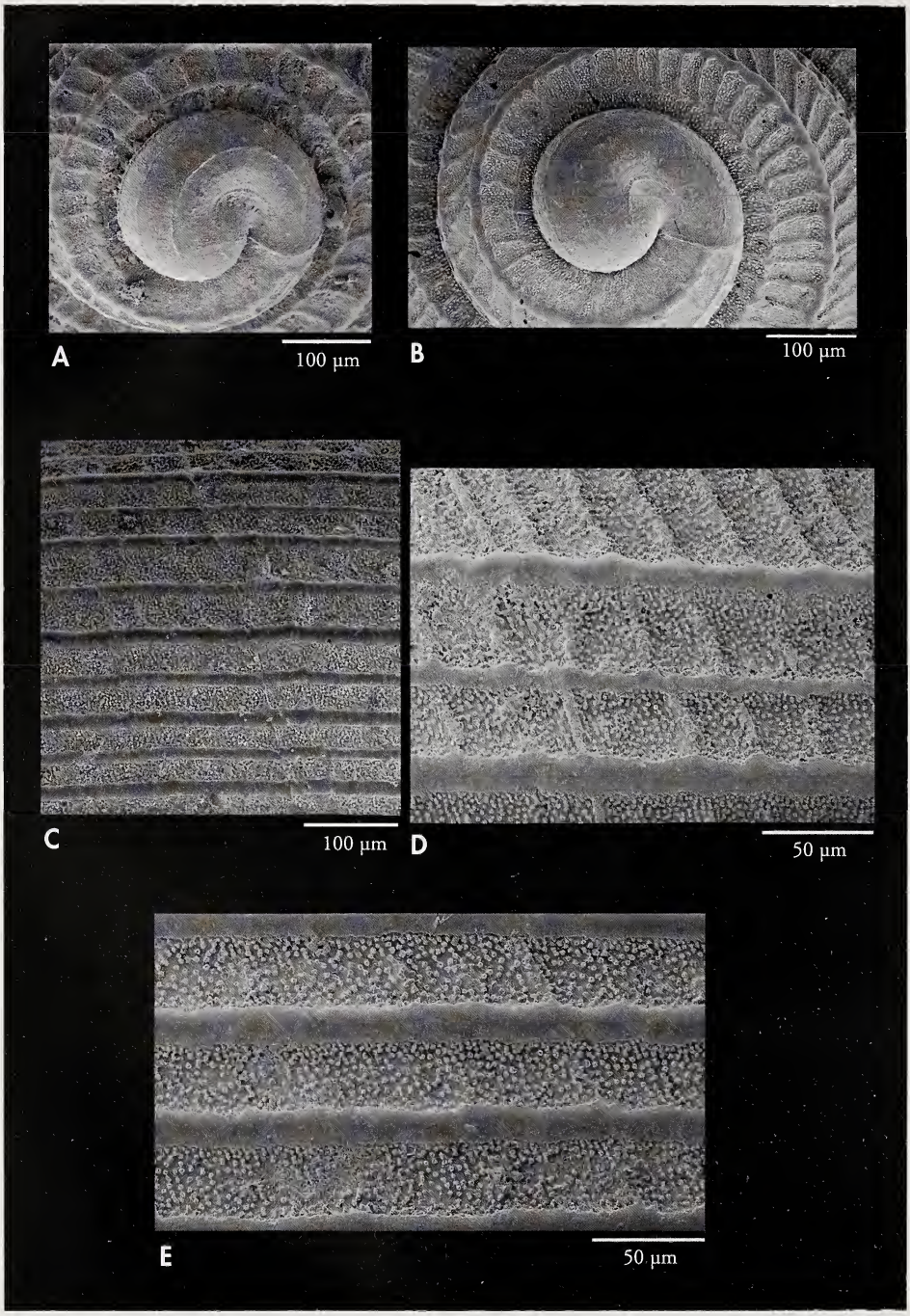

Figure 22. *Haplocochlias arrondoi* spec. nov. A: apex and protoconch of a paratype from MCZ; B: apex and protoconch of another shell (MHNS); C, E: microsculpture and detail of the last whorl.

Figura 22. Haplocochlias arrondoi *spec. nov. A: ápice y protoconcha de un paratipo de MCZ; B: ápice y protoconcha de otra concha (MHNS); C, E: microescultura y detalle de la última vuelta.*

lacks axial striae between cords. *H. harryleei* spec. nov. has a round periphery and a greater protoconch diameter.

The radula (Figs. 1A-B) differs from that figured by HICKMAN & MCLEAN (1990: 144, fig. 97B) for *H. cyclophoreus*, the type species of the genus, by having the central tooth narrower and the edge of the lateral teeth with finely serrated margins.

Haplocochlias harryleei spec. nov. (Figure 23)

Type material: Holotype deposited in FLMNH (457012).
Other material examined: None.
Type locality: Off Isla Escudo de Veraguas, Caribbean coast of Panama, dredged at 200 m (CHL).
Etymology: The specific name is after Harry G. Lee who presented the unique shell from his collection.

Description: Shell small, solid, rounded, with a spire formed by 4 ¾ rapidly-expanding whorls. The protoconch has ¾ whorls, about 230 μm in diameter and is apparently smooth, but under magnification 2 very fine spiral cordlets can be seen on its distal part. Teleoconch with 4 spiral whorls; ornamentation formed by spiral cords which are of similar size which do not produce an angulation; between them there are axial striae and microtubercles. Four spiral cords can be seen at the beginning of the 1st and 2nd whorls, 5 on the third and 4th and between 26 and 28 on the last; the cords which are near the suture and the umbilicus are finer and closer. Periphery uniformly rounded. Aperture rounded; outer lip reflected outwards, frontally widened and not crenulated. Columella arched, reflected, reducing it the umbilicus to a small fissure.

Dimensions: The holotype is 3.03 mm in height and 3.11 mm in diameter.

Habitat: Found on the continental slope. Collected with dredgings at 200 m.

Distribution: Only known from Isla Escudo de Veraguas, Caribbean coast of Panama, its type locality.

Remarks: *Haplocochlias harryleei* spec. nov. may be distinguished from the other known species because: the protoconch is apparently smooth, the periphery rounded, without keel or angulation, the umbilicus is almost closed, and the outer lip and the columella are reflected externally and widened frontally.

H. cubensis has a greater number of spiral cords and lacks axial striae between cords. *H. arrondoi* spec. nov. has an angled periphery.

moolenbeeki group

Remarks: The main differential characteristic of this group is the border of the outer lip being denticulate due to the projection of the spiral cords on its outer margin; the lip is not thickened nor reflected outwards. Another differential characteristic is the presence of a depressed triangular area at the intersection of the outer lip, columella and periumbilical cord.

The name employed for this group is not that of the oldest described species but that of the most characteristic morphologically.

Haplocochlias moolenbeeki De Jong & Coomans, 1988 (Figure 24)

Haplocochlias swifti auct. non Vanatta, 1913.
Haplocochlias moolenbeeki de Jong & Coomans, 1988. *Studies on the Fauna of Curaçao and other Caribbean Islands* 69: 16, pl. 1, fig. 53 [Type locality: Aruba, harbour].

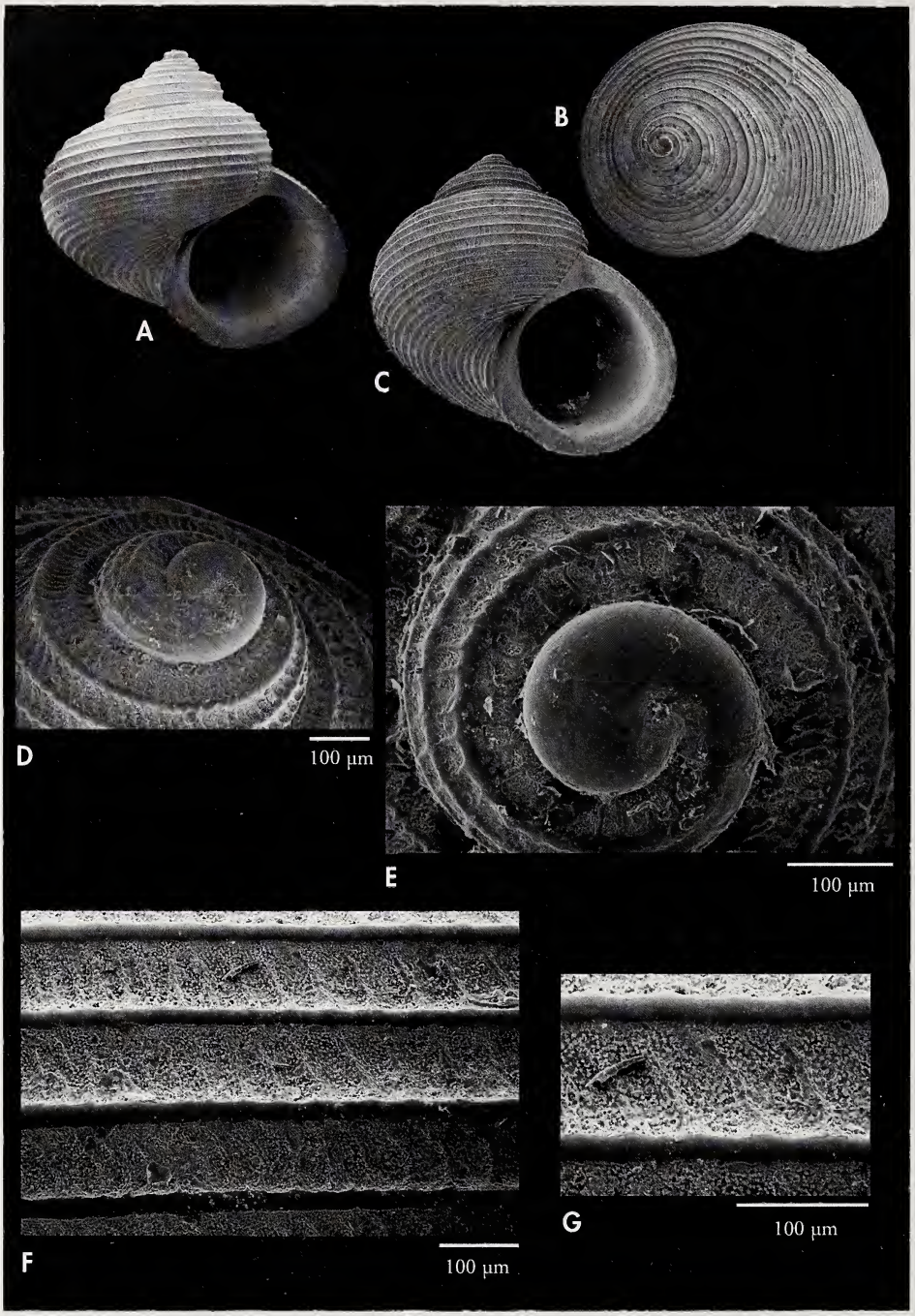

Figure 23. *Haplocochlias harryleei* spec. nov. A-C: holotype, diameter 3.11 mm, Isla Escudo de Veraguas, Caribbean coast of Panama (FLMNH); D, E: apex and protoconch of the holotype; F, G: microsculpture and detail of the last whorl.

Figura 23. Haplocochlias harryleei *spec. nov. A-C: holotipo, diámetro 3,11 mm, Isla Escudo de Veraguas, costa caribeña de Panamá (FLMNH); D, E: ápice y protoconcha del holotipo; F, G: microescultura y detalle de la última vuelta.*

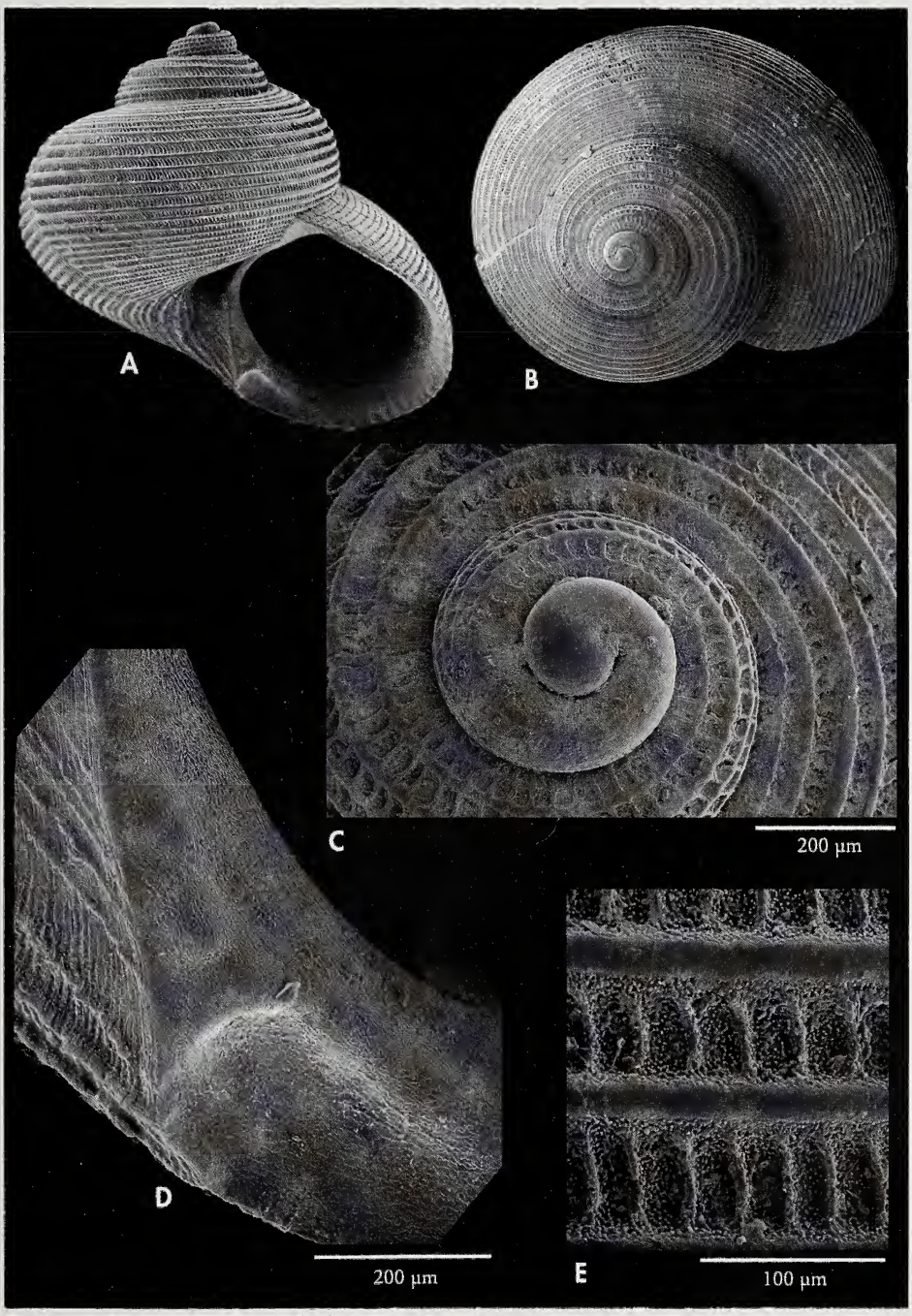

Figure 24. *Haplocochlias moolenbeeki* de Jong & Coomans, 1988. A, B: paratype, 2.80 × 2.92 mm (MHNS ex coll. Verberne); C: protoconch; D: base of the columella, detail; E: microsculpture of the last whorl.

Figura 24. Haplocochlias moolenbeeki *de Jong & Coomans, 1988. A, B: paratipo, 2,80 × 2,92 mm (MHNS ex col. Verberne); C: protoconcha; D: base de la columela, detalle; E: microescultura de la última vuelta.*

Type material: The holotype of *Haplocochlias moolenbeeki* is deposited in ZMA (now Naturalis, Leiden; nº 2.87.050) (not examined); 17 paratypes in coll. F. Verberne deposited in ZMA (of which one now in MHNS donated by Robert Moolenbeek).
Other material examined: None.

Description: Original description of *H. moolenbeeki* in DE JONG & COOMANS (1988: 16): *"The shell has 1 ½ nuclear and 4 postnuclear whorls. Aperture round, outer lip thickened, umbilicus present. The body whorl has 18 very fine spirals above the aperture, and two perceptibly more prominent spirals on the periphery (with one spiral in between); the penultimate whorl has 9 spirals"*.

The shell is turbiniform, strong and solid, with a spire formed by 4 ½ whorls that increase rapidly, separated by a marked suture. The protoconch has ¾ whorl, is totally smooth, lacks a labial varix and measures 215 μm in diameter. The teleoconch has 3 ¾ whorls and is ornamented by spiral cords and axial striae with micro tubercles in their interspaces. In apertural view we see 4 cords in the first whorls, 5 in the second and 32-34 in the last one; the cords are of regular size and distribution, without any peripheral carinae or a periumbilical larger cord; in the last half whorl the cords are more numerous and the interspaces between cords are reduced to a small groove. The axial striae in the first whorl are more separate and form rectangular hollows, later are more numerous and have closer interspaces. The surface of the hollows appears covered by micro tubercles.

Aperture rounded, prosocline. Parietal area covered by a very fine callous coat; columella arched, wider at the base, where 2 small protuberances can be seen. External lip sharp, the border crenulated by the presence of the spiral cords, not denticulate inside; on its base, near the columella a triangular depression can be seen. Umbilicus relatively wide, delimited by several spiral cords not very wide; inside 5-6 fine cordlets can be seen.

Dimensions: Holotype size: 4.4 in height, 4.7 mm in diameter. (H/D: 0,94)

The paratype studied measures 2.80 mm in height and 2.92 mm in diameter. A specimen from Peanut Island, Palm Beach Co., Florida, USA is reported 5.5 mm (<www.jaxshells.org>, in Selected Western Atlantic Gastropods, edited by Harry Lee)

Habitat: Among rocks on east side Peanut Island, Palm Beach Co., Florida, USA (<www.jaxshells.org>).

Distribution: *H. moolenbeeki* has been recorded from Colombia (DÍAZ *ET AL.*, 1990), Aruba and Curacao (DE JONG & COOMANS, 1988).

Remarks: The type of *H. moolenbeeki* could not be examined because the ZMA is in a period of restructuring and moving to Leiden. Only a paratype could be examined (Figs. 24A-B).

DE JONG & COOMANS (1988) remarked: "H. moolenbeeki *was figured by* ABBOTT *(1974, fig. 457) as* H. swifti, *which species is not umbilicated and has less spirals, a thicker outer lip and carinae*".

So, the only samples available for comparison are: that of DE JONG & COOMANS (1988: fig. 53, a drawing) and that of ABBOTT (1974, fig. 457). Actually, *H. moolenbeeki* differs from *H. swifti* mainly in lacking a thickening of the outer lip and because it is umbilicate, although its umbilicus is reduced to a small fissure.

The Cuban record of *H. moolenbeeki* by ESPINOSA *ET AL.* (1995) was later rejected by ESPINOSA, FERNÁNDEZ-GARCÉS & ROLÁN (2005) prior to the description of *H. nunezi* without explanation; also, there is no comparison between *H. nunezi* and *H. moolenbeeki* in that paper. The differences with *H. nunezi* are: *H. moolenbeeki* has a smooth protoconch; it lacks carinae which form an angle on the periphery of the shell; the spiral cords are regular in size and in distribution; its umbilicus is wider with 6 fine cordlets inside; it has two denticles on the base of the columella and a triangular depression on the base of the internal lip.

Haplocochlias nunezi Espinosa, Ortea & Fernández-Garcés, 2005 (Figures 25-27)

Haplocochlias sp. A. Redfern (2001), *Bahamian Seashells* 15, figs. 66A-C.
Haplocochlias nunezi Espinosa, Ortea & Fernández-Garcés, 2005. *Avicennia* 17: 74, figs. 2A-C. [Type locality: in front of the Instituto de Oceanología, La Habana, Cuba, 1.5 m].

Type material: The holotype of *Haplocochlias nunezi* is in IES, CITMA, Havana, Cuba.
Material examined: Cuba: 1 s, Havana, 1.5 m (MHNS). Nicaragua: 1 s, Witties, 15 m (MHNS). USA, Florida: 2 s, rocky reef, 45 m, Palm Beach (MCZ, 207094, in coll. McGinty as *H. swifti*); 1 s, Off Palm Beach, 54 m (MCZ 226853, in coll. McGinty as *H. swifti*); 1 s, 95 mi W Egmont Key, Hillsborough Co., dredged 76 m (CHL); 1 s, Fowey Rocks reef, Miami, Florida, under rubble, 3-3.6 m (CHL); 2 s, Off Palm Beach, Florida, 54 m (coll. McGinty, MCZ n° 226853 and 207094); 1 s, Monroe County, Molasses Reef, Upper Florida Keys, 7 m (FMNH 288191); 1 s, Monroe County, 24° 32′ 47″N, 081° 24′ 20″W, Looe Key back reef, Lower Florida Keys, 2.0 m (FMNH 288338); 1 s, Monroe County, 24° 32′ 48″N, 081° 24′ 48″W, Looe Key back reef, Lower Florida Keys, 6 m (FMNH 3008318); 1 s, Monroe County, off Halfmoon Shoal, 13 m (FMNH 328622); 1 s, Monroe County, Marquesas transect, in sand, 9 m (FMNH 328631); 1 s, Monroe County, 24° 27′ 31″N, 082° 12′ 22″W, Marquesas rock, 8 m (FMNH 330450); 1 s, Monroe County, The Horseshoe, off Marathon, 24° 39′ 55″N, 080° 59′ 34″W, 9 m (FMNH 330453); 1 s, Monroe County, Ramrod Key transect, W edge of Looe Key, 24° 33′ 06″N, 081° 25′ 56″W 10 m (FMNH 331907); 1 s, Monroe County, Dry Tortugas transect, 24° 32′ 00″N, 082° 56′ 29″W, 20.2 m (FMNH 333912). Bahamas: 67 s, Abaco Island, beach drift (CCR); 47 s, Abaco Island, 7 m, in coralline sediment (CCR); 1 sp, Abaco Island, live on the underside of a rock on the reef in 4.5 m (CCR); 1 s, Abaco Island, 35 m, in coralline sediment (CCR); 1 s, West End, Grand Bahama Island, beach (CHL); 1 s, N Current Cut, Eleuthera, beach (CHL); 1 s, South Riding Rocks, Cay Sal Bank, bottom sample 18 m (CHL); 1 s, Long Cay Mooring, Long Cay, bottom sample, 29 m (CHL). British Virgin Islands: 1 s, Deadman Chest, bottom sample, 18 m (CHL). Mexico: 1 s, Puerto Morelos, Yucatan, Mexico, 10-16 m (MHNS).

Description: Original description of *H. nunezi* in ESPINOSA *ET AL.* (2005).

To the original description we add: The shell of this species is large in comparison with the others of the genus (adult shells measure between 5.0 in height and 6.1 mm in diameter; H/D: 0.91); its spire is formed by 4.5-5 whorls. Ornamentation formed by spiral cords and axial striae, with microtubercles in the spaces between cords. The presence of 4 peripheral cords angulates the shell giving it a characteristic aspect; between them, there are other smaller spiral cords, whose number varies in relation to the degree of development of each individual. On the last whorl of the holotype there are 16 cordlets between the suture and the upper keel; 7 between the first and the second; 6 between the second and the third; 4 between the third and the fourth and approximately 20 between the fourth and the umbilicus.

Aperture rounded, peristome continuous, barely adherent. Outer lip sharp, margin denticulate by the presence of cords and keels. Columella straight, is widened at the base, forming a triangular area in the intersection point between the outer lip, columella and periumbilical cord. Umbilicus narrow and deep, limited by a strong cord, 2-3 very fine cordlets can be observed within.

Dimensions: Maximum reported size: 6.3 mm high x 6.1 mm diameter (coll. McGinty, MCZ 226853 as *H. swifti*).

Habitat: Living specimens were collected in shallow water under rocks near the reef between 1.5 and 4.5 m in depth. Empty shells have been taken from sediment found between 5 and 53 m in depth.

Distribution: *H. nunezi* has been recorded in the Bahamas: Abaco (REDFERN, 2001 as *Haplocochlias* sp. A) and Grand Bahama Island (from material at ANSP); Cuba: North Havana Province (ESPINOSA *ET AL.*, 2005) USA: Florida Keys; Nicaragua: Witties; British Virgin Islands: Deadman Chest and

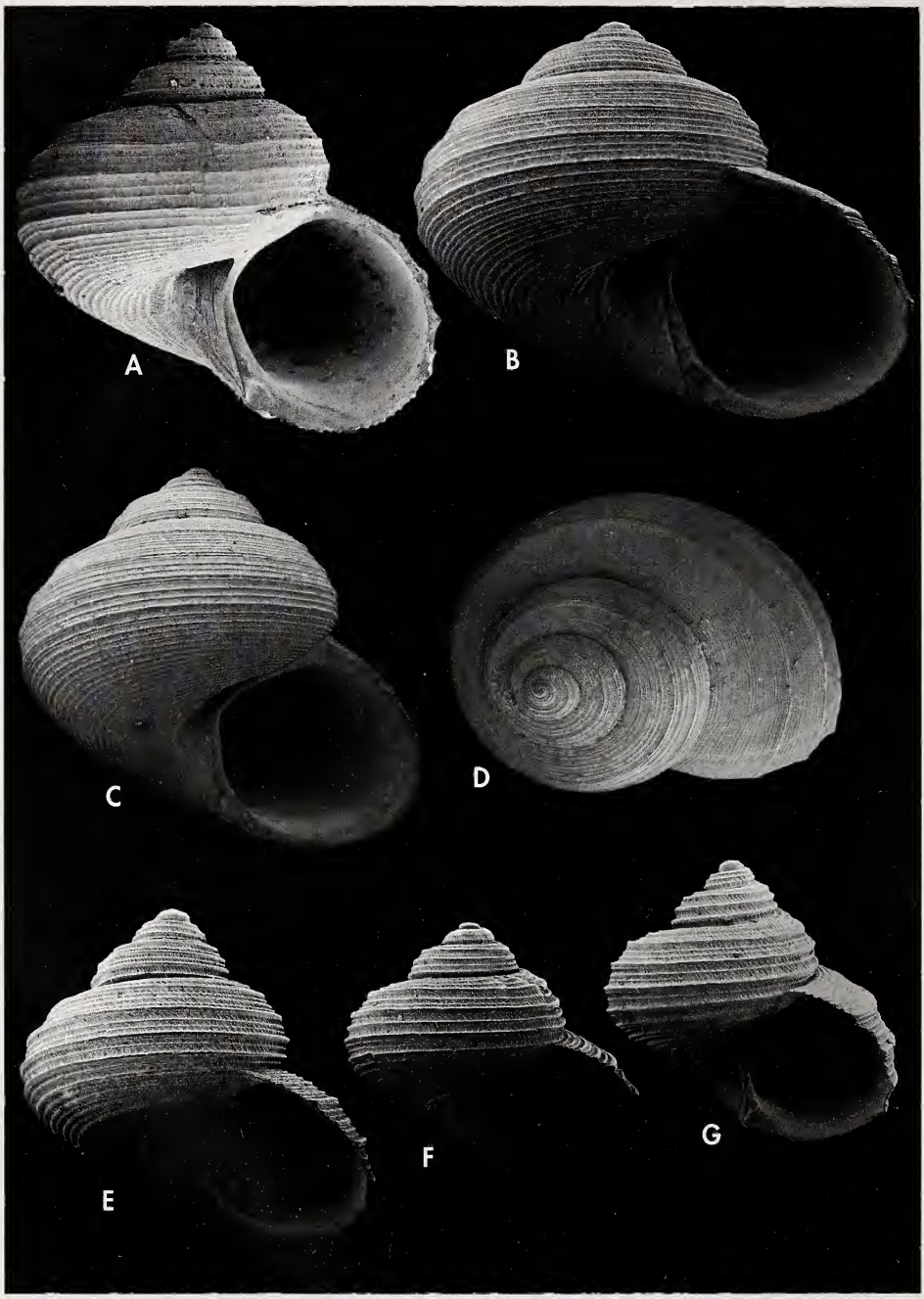

Figure 25. *Haplocochlias nunezi* Espinosa, Ortea & Fernández-Garcés, 2005. A: shell, diameter 5.43 mm, 95 miles W of Egmont Key, Hillsborough Co., Florida (CHL); B-F: shells, 5.39, 4.5, 4.5, 3.95, 2.8 mm, Abaco Island, Bahamas (CCR); G: shell, 2.8 mm, Havana, Cuba (MHNS).
Figura 25. Haplocochlias nunezi *Espinosa, Ortea & Fernández-Garcés, 2005. A: concha, diámetro 5,43 mm, 95 millas al oeste de Egmont Key, Hillsborough Co., Florida (CHL); B-F: conchas, 5,39, 4,5, 4,5, 3,95, 2,8 mm, Abaco Island, Bahamas (CCR); G: concha, 2,8 mm, Habana, Cuba (MHNS).*

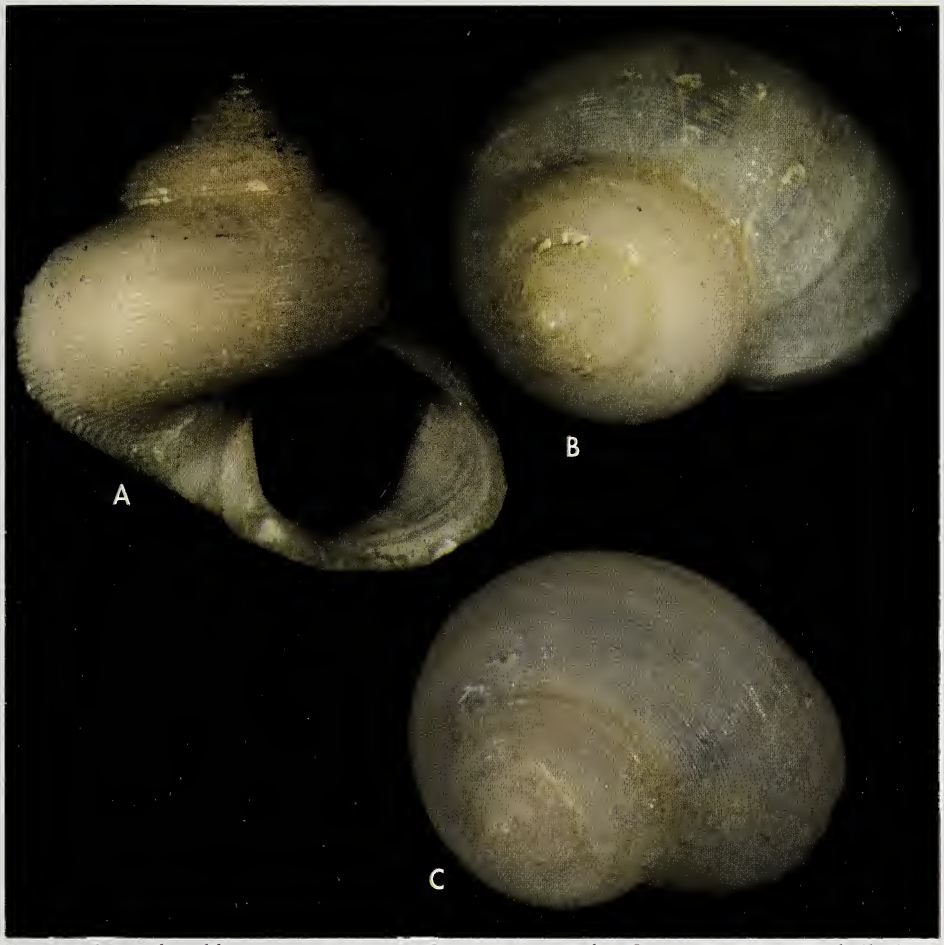

Figure 26. *Haplocochlias nunezi* Espinosa, Ortea & Fernández-Garcés, 2005. A, B: shell, 6.3 × 6.1 mm, off Palm Beach, Florida, USA, 55 m (identified as *H. swifti* in coll. McGinty, MCZ 226853); C: shell, diameter 5 mm, Palm Beach, Florida (as *H. swifti* in coll. McGinty, MCZ 207094).

Figura 26. Haplocochlias nunezi *Espinosa, Ortea & Fernández-Garcés, 2005. A, B: concha, 6,3 × 6,1 mm, frente a Palm Beach, Florida, EE.UU., 55 m (identificado como* H. swifti *en col. McGinty, MCZ 226853); C: concha, diámetro 5 mm, Palm Beach, Florida (como* H. swifti *en col. McGinty, MCZ 207094).*

Mexico: Puerto Morelos, Yucatan, in the present work.

Remarks: The specimen of *H. nunezi* we examined (Fig. 19G) from Cuba, is less than 3 mm in diameter and so has not undergone the same degree of development as the holotype (5.7 mm in diameter); although we consider it as an adult individual it has not developed the same number of cords mentioned for the holotype. Otherwise it is identical with respect to all other characteristics.

In this particular specimen the columella is widened near the base, being reflected towards the umbilicus, giving the impression that it is straight and not arched; also the umbilicus is narrower than in all other adult shells examined.

The characters cited below are valid for the identification of juvenile individu-

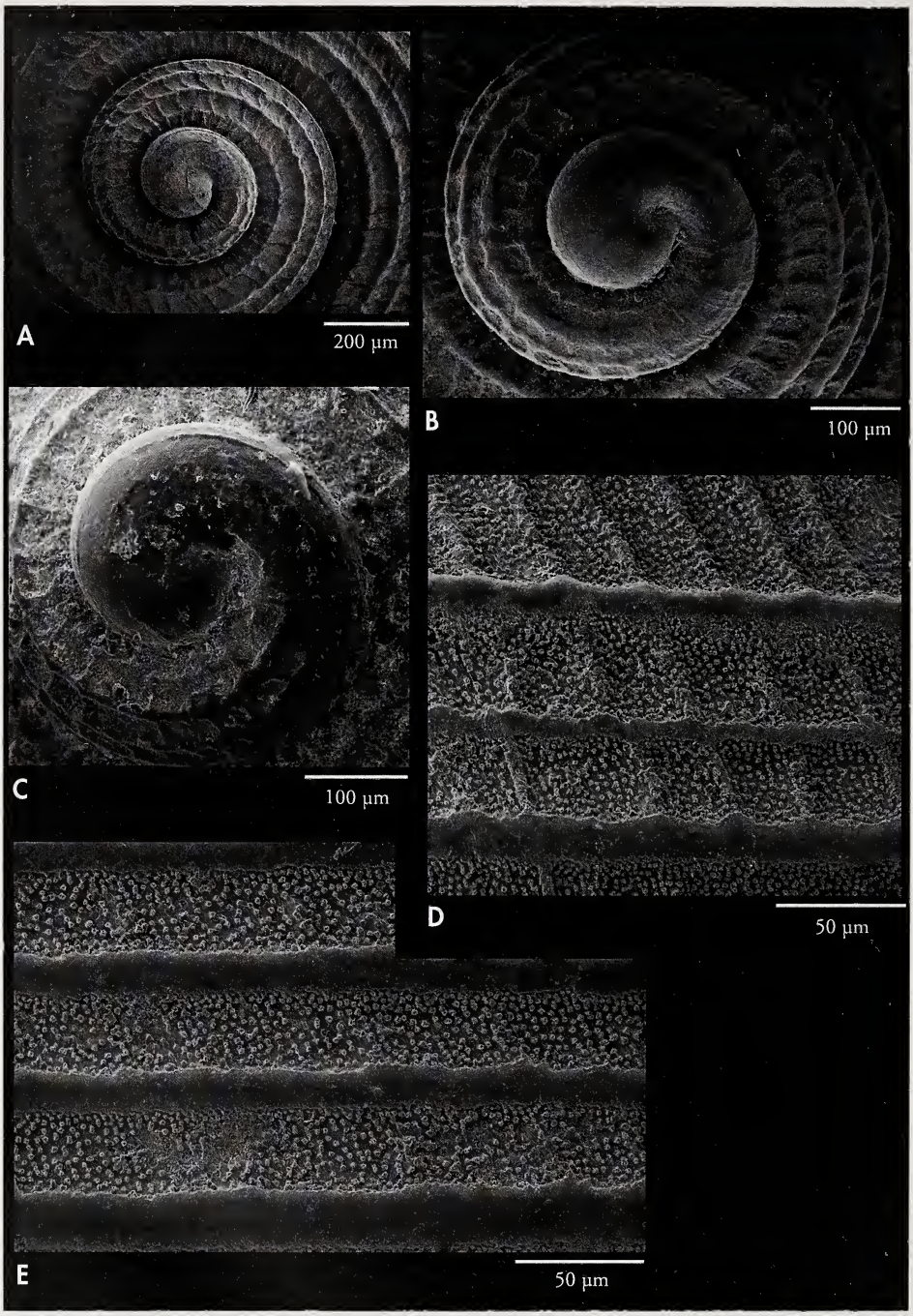

Figure 27. *Haplocochlias nunezi* Espinosa, Ortea & Fernández-Garcés, 2005. A: apex, shell from Yucatan, Mexico (MHNS); B: protoconch, Nicaragua; C: protoconch, Florida; D-F: microsculpture of the last whorl.

Figura 27. Haplocochlias nunezi *Espinosa, Ortea & Fernández-Garcés, 2005. A: ápide, concha de Yucatan, Mexico (MHNS); B: protoconcha, Nicaragua; C: protoconcha, Florida; D-F: microescultura de la última vuelta.*

als as well as fully adult shells: (1) presence of 4 keels on the periphery of the last whorl, (2) umbilicus rather constricted, (3) columella straight and also the triangular space at the intersection of the outer lip with the columella and periumbilical cord, (4) outer lip crenulated.

The species was misidentified as *H. swifti* by ROSENBERG (1992: 42), who illustrated specimens from Grand Bahama Island (ANSP 370100) and whose Florida record is based on ANSP 181317 from Missouri Key and ANSP 313313 from off Palm Beach, being subsequently referred to *H. nunezi* by ROSENBERG *ET AL.* (2009). *Haplocochlias* sp. A of REDFERN (2001) was referred to *H. nunezi* by ESPINOSA *ET AL.* (2005).

Haplocochlias nunezi is the most widely distributed species of the genus in the Caribbean, having been found from Florida to the Witties, Nicaragua. It is found in mainland as well as insular coastal waters. On some islands such as Abaco (Bahamas) populations must be very dense judging from the large number of shells found.

H. nunezi may be distinguished from *H. moolenbeeki* by the larger size of its protoconch and by having cords on its surface; by having 4 cords which look as carinae and form angles at the periphery of the shell; by having the columella almost straight and reflected towards the umbilicus, which in adult shells is reduced to a narrow fissure.

Haplocochlias calidimaris (Pilsbry & McGinty, 1945) (Figure 28)

Parviturbo calidimaris Pilsbry & McGinty, 1945. *Nautilus* 59: 56-57, pl. 6, fig. 4. [Type locality: 1 ½ miles off Cape Florida].

Type material: Holotype in ANSP (181319), paratypes in Weber and McGinty collections. Examined a photograph of the holotype sent by ANSP (Fig. 28A).
Material examined: USA, Florida: 3 s, Monroe County, Dry Tortugas trancset Sta. D-21-FK-570, Florida Keys, 30 m (FMNH 333911).

Description: This is the original description in PILSBRY & MCGINTY (1945: 56-57): "*The moderately solid but not thick white shell is broadly turbinate, with a moderately elevated conic spire, rounded last whorl and rather narrow umbilicus, the last whorl encircled by ten major spiral cords. There are 3 ¾ strongly convex whorls, with a deep suture. The initial 1 ½ smooth, rounded whorls form the rather projecting nuclear shell. Following whorl matt, rounded (worn?), with traces of spiral cords at first, becoming well developed on its last half. Penult whorl has three strong spiral cords and a smaller one below the suture; the last whorl has about ten high, narrow spiral cords, those at and above the periphery are more widely spaced, with an interstitial spiral thread in the last half whorl. All of the intervals are crossed by low, fine axial threads. The umbilicus is small, its walls smooth within, and bounded by a high cord. The aperture is subcircular. Peristome thin, the outer margin scalloped, columella narrow, nearly straight. Parietal callus rather thin*".

Diameter 2 mm, height 1.75 mm.

The protoconch has ¾ of whorl, measuring about 260 μm, and it has 3 spiral cords on its surface and a thick labial varix.

The teleoconch has 2 ½ whorls and is covered entirely by spiral cords, axial grooves and microtubercles in the interspace between cords. In apertural position the shell shows 3 cords in the first whorl and 9-10 on the last whorl. The cords are very prominent, narrower than the interspaces, which are concave and are covered by axial striae very regular in size and disposition.

Inside the umbilicus 2-3 spiral cordlets can be seen; also fine axial grooves, more numerous and dense than those located in the spaces between cords.

The outer lip is crenulated so as to form a scalloped margin, not thickened or with denticles on its inner side, modi-

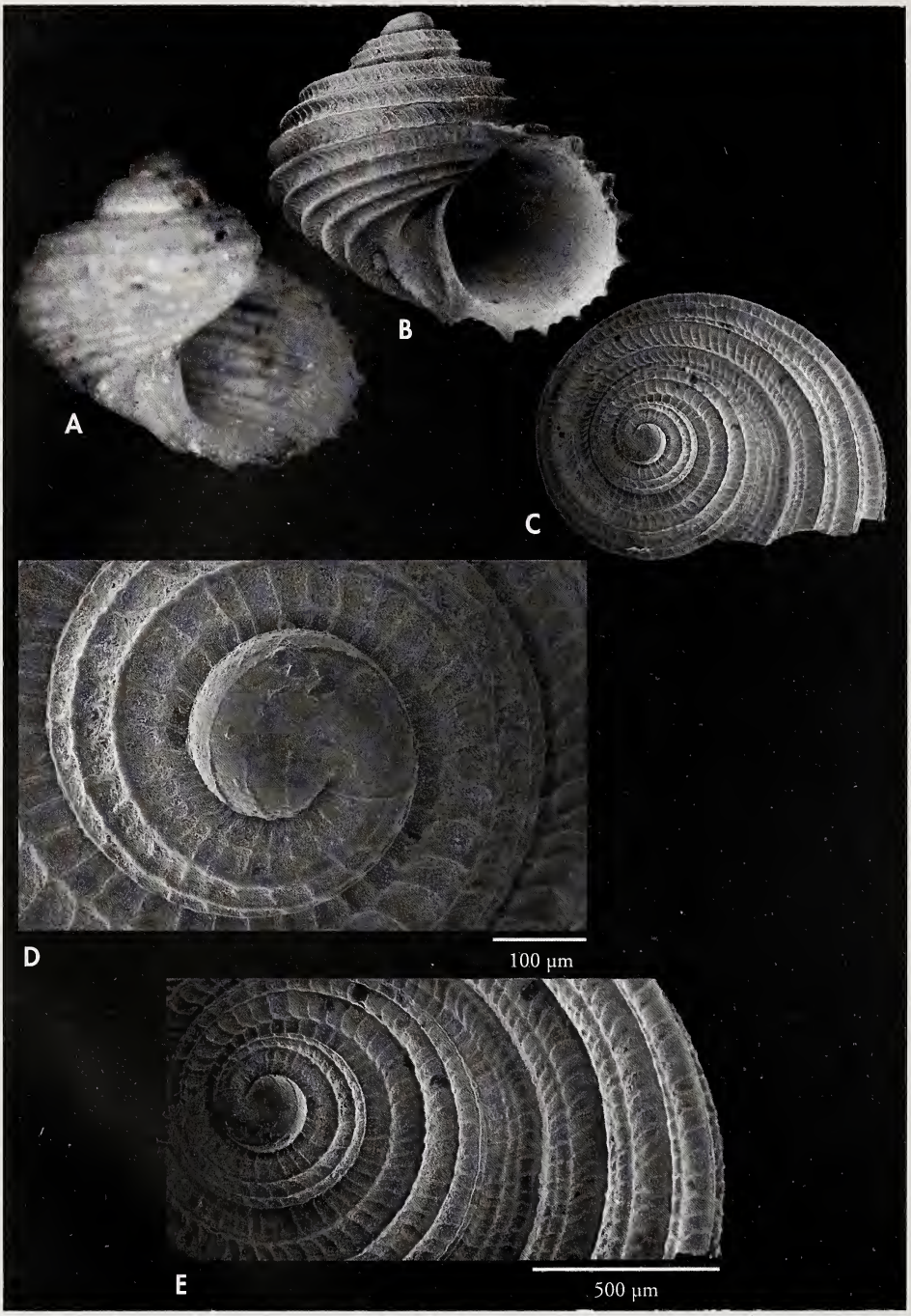

Figure 28. *Haplocochlias calidimaris* (Pilsbry & McGinty, 1945). A: holotype, diameter 2.0 mm (ANSP 181319); B, C: shell, apical and apertural view, diameter 1.8 mm (FMNH 333911); D: protoconch, same shell; E: apex and microsculpture.

Figura 28. Haplocochlias calidimaris *(Pilsbry & McGinty, 1945). A: holotype, diámetro 2,0 mm (ANSP 181319); B, C: concha, vista apical y apertural, diámetro 1,8 mm (FMNH 333911); D: protoconcha de la misma concha; E: ápice y microescultura.*

fied by many spiral cords that determine its outline.

A shell studied measures 1.62 mm in height and 1.81 mm in diameter (H/D: 0.9).

Habitat: This is probably a subtidal species, living under stones, in 70 ft (21 m). North Inlet of Lake Worth, Palm Beach and Ft. Myers Beach, Florida (PILSBRY & MCGINTY, 1945). At 20 m deep (ABBOTT, 1974).

Bathymetric range: 0 to 21 m

Distribution: USA: Florida: East Florida, West Florida (PILSBRY & MCGINTY, 1945); South half of Florida (ABBOTT, 1974); Moín, Costa Rica (ROBINSON & MONTOYA 1987). Range: 26.8°N to 10.01°N; 83.08°W to 80°W.

Remarks: PILSBRY & MCGINTY (1945: 57) indicated: "*This species has more spiral cords than* C. *[error for* Parviturbo*]* weberi *and lacks the imperfect axial folds which make the upper and the lowest cords nodulose in that species. It is similar in figure to* P. francesae *[now* Haplocochlias francesae*], but is much smaller, and the last half whorl has a spiral thread in the intervals (not showing in the face view). It differs from* P. zacalles *by the same character, and also by the form of the umbilicus and the columella. Possibly none of the specimens are fully adult, as the lip is still thin, not thickened as in similar species; but the sculptural characters show that it is not the immature stage of any other known species.*

The epipodial cirri have been observed in specimens from the North Inlet of Lake Worth".

Since its original description, *Parviturbo calidimaris* has not been recorded in any malacological work, except by ABBOTT (1974); this work being a compilation of the American species of known mollusks only mentions the area where the type material was found, Florida. ROBINSON & MONTOYA (1987) recorded this species from Moin, Costa Rica, but this mention requires confirmation, because on the basis of the material studied, we believe that the area of distribution of *P. calidimaris* is confined to the Floridan coast.

The larger number of spiral cordlets, the absence of axial lamellae in the interspaces and of nodose cordlets, among other characters, prompted us to transfer this species to the genus *Haplocochlias*.

In our opinion, the species with which *Haplocochlias calidimaris* has most similarity is *H. francesae*, species with which it shares, in addition to certain morphological characters, the bathymetric range and habitat. *Haplocochlias calidimaris* differs from *H. francesae* by having the protoconch ornamented with spiral cordlets, because it has the edge of the outer lip modified by the presence of spiral cords and the cordlets in their interspace (18-20 can be observed on the edge of the outer lip), and also in having the umbilicus wider and with 2-3 fine spiral cordlets and axial striae that are very dense inside.

Haplocochlias pacorubioi spec. nov. (Figures 29, 30)

Type material: Holotype (15.05/60044, Figs. 29A-B) and 1 paratype deposited in MNCN (15.05/60045). Others paratypes in the following: MNHN (IM-2012-2522, 1 s, Fig. 29C), MCZ (377779, 1 s, Fig. 29D), MHNS (100575, 1 s), IES (1 s), all from type locality.

Other material examined: Cuba: 1 s, Cayo Matias, Archipelago of Canarreos, 18 m (MHNS); 1 s, Guajimico, 2 m (MHNS); 4 s, Cienfuegos, 35 m (MHNS); 1 s, Rancho Luna Beach, 40 m (MHNS); 1 s, Rancho Luna Beach, 45 m (MHNS).

Type locality: Rancho Luna Beach, Cienfuegos, Cuba, at 35 m.

Etymology: The species name is dedicated to Francisco (Paco) Rubio, brother of the first author recently passed away.

Description: Shell of small size, robust, almost as wide as high, turbiniform, spire comprised of 4 ½ whorls separated by a deep suture. Protoconch totally smooth without spiral cordlets, measuring about 210 μm, and ¾ whorl. Teleoconch 3 ¾ whorls. Ornamentation formed by spiral cords of varying cali-

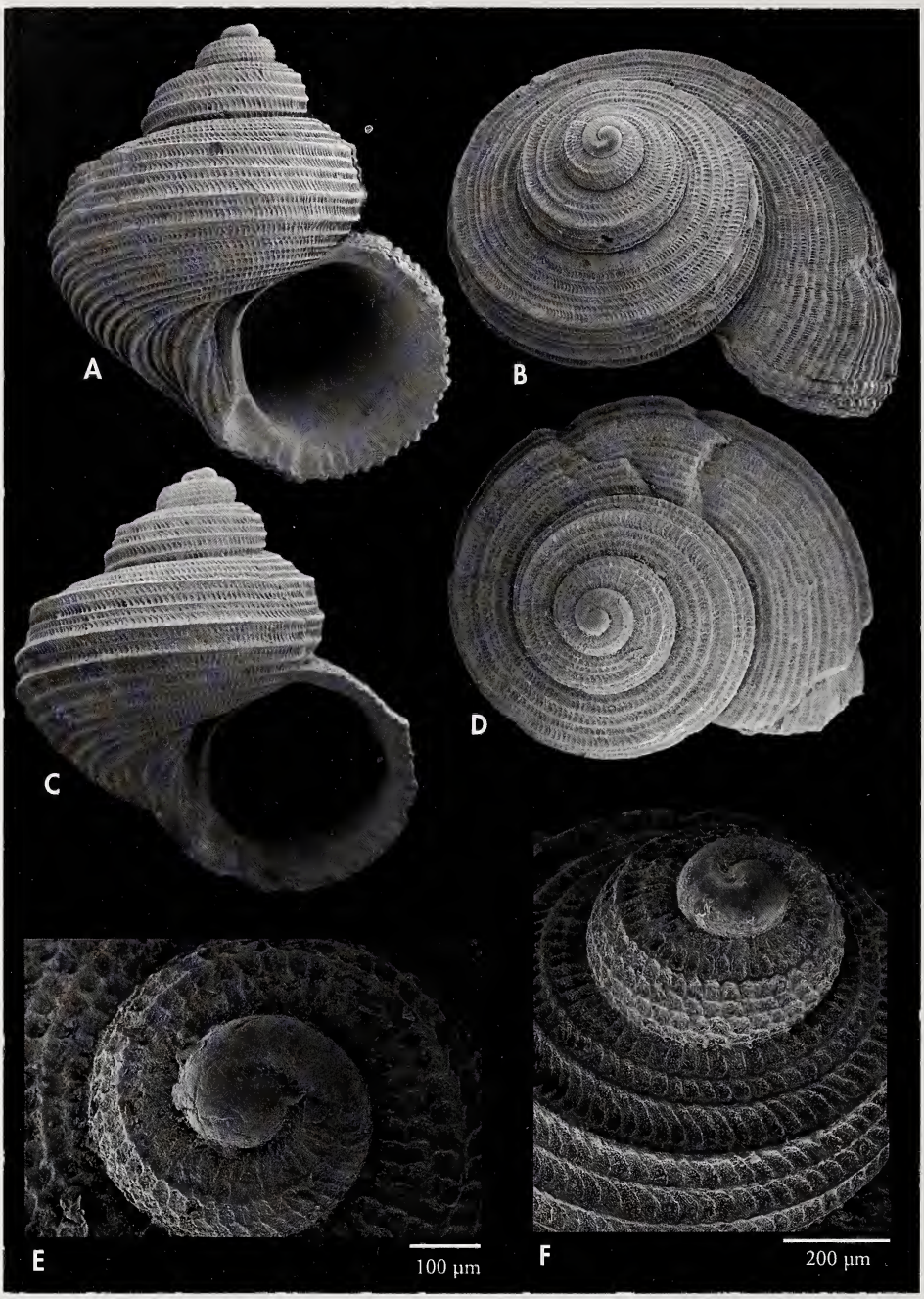

Figure 29. *Haplocochlias pacorubioi* spec. nov. A: holotype, 2.81 mm height × 2.5 mm diameter (MNCN); B: paratype, 3.0 mm (MNCN); C: paratype, 2.6 mm height (MNHN); D: paratype, height 2.3 mm (MCZ), all from Rancho Luna Beach, Cienfuegos, Cuba; E, F: apex and protoconch.

Figura 29. Haplocochlias pacorubioi spec. nov. A: holotipo, 2.81 mm altura x 2.5 mm diámetro (MNCN); B: paratipo, 3.0 mm (MNCN); C: paratipo, altura 2.6 mm (MNHN); D: paratipo, altura 2.3 mm (MCZ), todos de Playa Rancho Luna, Cienfuegos, Cuba; E, F: ápice y protoconcha.

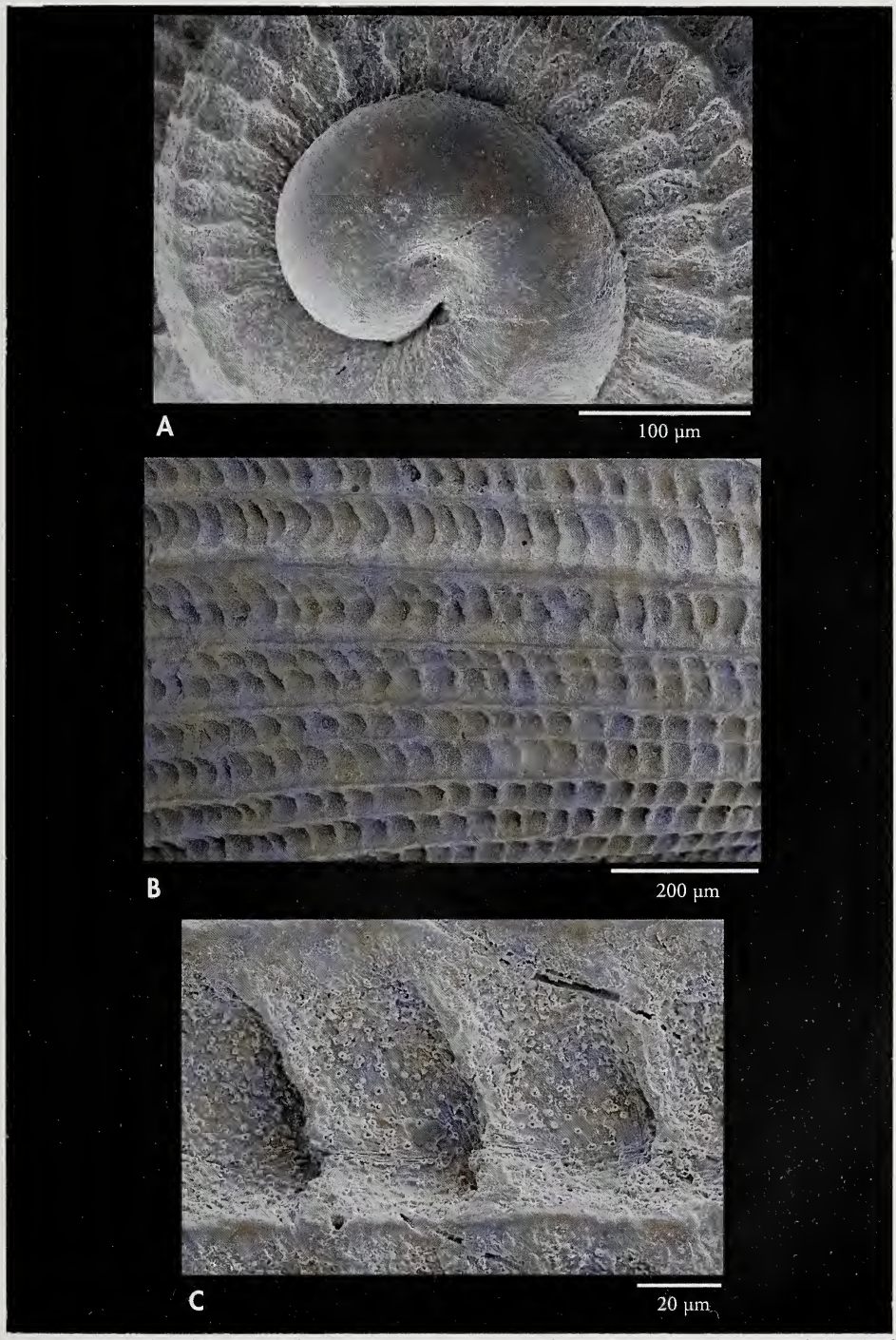

Figure 30. *Haplocochlias pacorubioi* spec. nov. A: protoconch; B, C: microsculpture and detail of last whorl.

Figura 30. Haplocochlias pacorubioi *spec. nov. A: protoconcha; B, C: microescultura y detalle de la última vuelta.*

bre, and by axial striae and microtubercles in the interspaces between cords. On the first whorl the striae are crossed by the cords forming cells of regular size; after the second whorl the striae are fused and become arched resembling small spirally aligned fish scales. The spiral cords are distributed thus: 4 on the first whorl; 6 on the second, of which the fourth is peripheral and more prominent; 12 on the third whorl, of which 5, 9 and 11 are more prominent producing an angulation of the periphery; on the last whorl the number of cords is between 40 and 46, of varying size.

Aperture rounded, almost circular, peristome barely adherent. Columella thickened, not reflected; on the inner lip there is a wide and concave area at the intersection with the umbilical cords; outer lip with sharp border and denticulate, its inner aspect with crenulations corresponding to the outer end of the spiral cords.

Umbilicus reduced to a narrow fissure, within which some cords are visible.

Dimensions: The holotype measures 2.81 mm in height and 2.50 mm in diameter. The largest paratype is 3.4 mm in diameter.

Habitat: The shells were collected in sediment from a coralline bottom at between 18 and 35 m.

Distribution: Only known from the south coast of Cuba at Cayo Matías (archipelago of Los Canarreos) and Rancho Luna Beach, Cienfuegos.

Remarks: *Haplocochlias pacorubioi* spec. nov. may be distinguished from the other species of the genus by the completely smooth protoconch, the presence of three strong peripheral cords forming keels which make the shell angulate, the axial striae in the shape of scales, the outer lip with a denticulate border and inner crenulation, and the umbilicus, which is reduced to a narrow fissure.

Another character that distinguishes the species from its congeners is the pentagonal cells on the first whorl of the teleoconch which disappear where the axial striae are joined together.

H. moolenbeeki differs by its larger size, having a larger protoconch with cords, and a greater number of spiral cords on the last whorl.

H. panamensis has fewer spiral cords, a smaller protoconch diameter, and numerous elongate and less prominent denticles.

Haplocochlias erici (Strong & Hertlein, 1939) (Figure 31)

Liotia erici Strong & Hertlein, 1939. *Allan Hancock Pacific Expeditions*, 2: 237, pl. 21 fig. 9. [Type locality: Bahia Honda, Isla Cohiba, Provincia de Vergara, Pacific coast of Panama].

Parviturbo erici (Strong & Hertlein, 1939): Keen (1971) *Sea shells of Tropical West America:* 345, fig. 123.

Type material: Holotype in California Academy of Sciences Paleont. (729). Not examined.
Material examined: Mexico, Pacific coast: 4 s, Puertecitos, Baja California (Gulf side), 1-3 m (LACM 64-31). Costa Rica, Pacific coast: 8 s, 1 mile offshore between Bahia Elena and Juanillo Bay, Guanacaste Province, 25-52 m (LACM 72-12); 4 s, 1 mile off beach, Bahia Brasilito, Guanacaste Province, 18 m (LACM 72-40); 13 s, anchorage inside small islet 1.5 km S of Punta Quepos, Puntarenas Province, 21 m, sandy bottom (LACM 72-57); 7 s, small islets off Quepos, Puntarenas Province, 22 m, gravel and cobble (LACM 72-59).

Description: The original description in Strong & Hertlein (1939) is as follows: "*Shell small, turbinate, solid, grayish white; nuclear whorls 1 ½, smooth, very small; postnuclear whorls 3 ½ well rounded, sutures slightly channeled; spiral sculpture of 4 raised threads on the first postnuclear whorl and 8 on the second; on the last whorl there are about 16 fine threads above the shoulder, followed by 12 slightly larger threads on the periphery and upper part of the base, umbilicus bordered by 2*

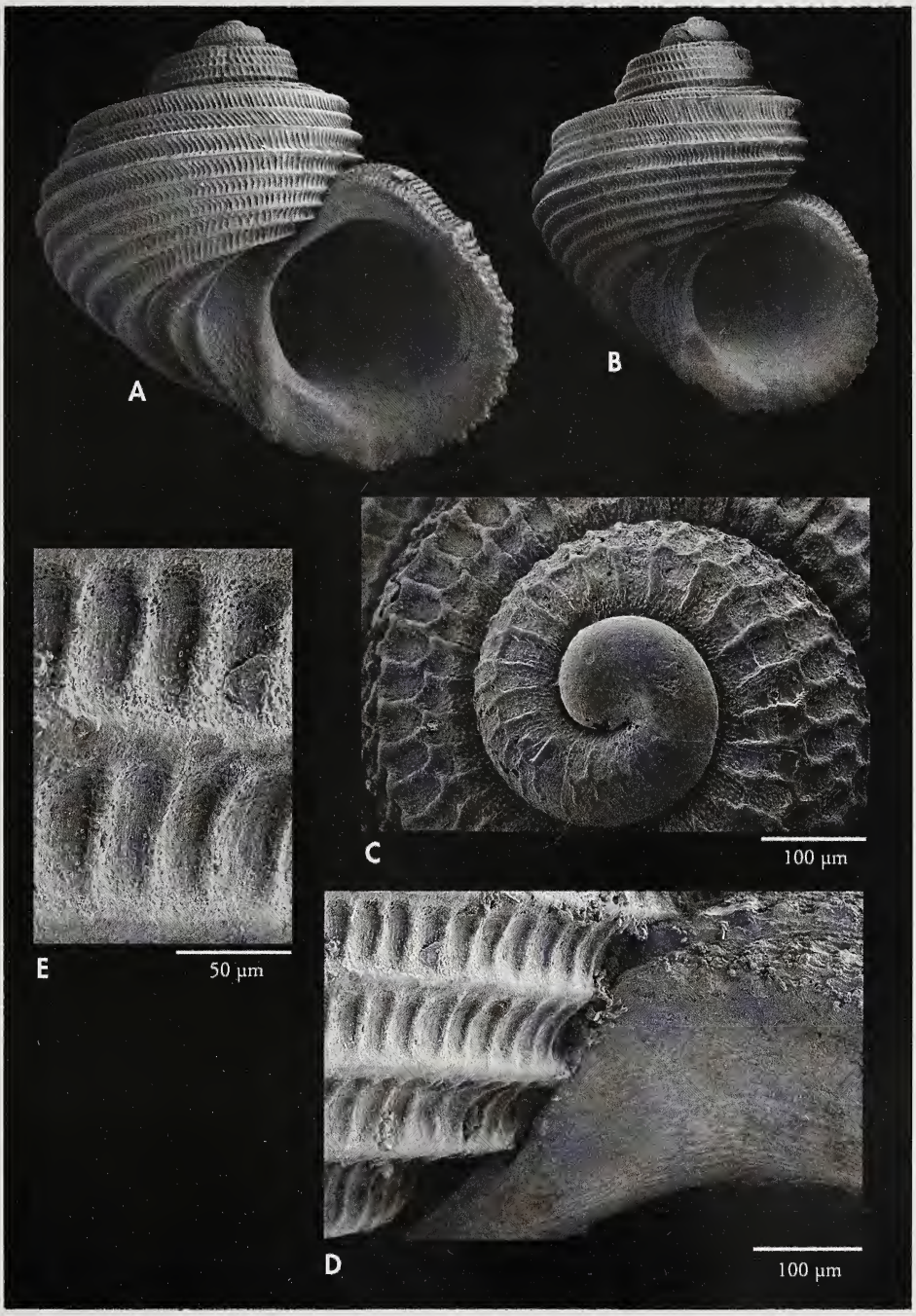

Figure 31. *Haplocochlias erici* (Strong & Hertlein, 1939). A, B: shells, diameter 2.45 mm and 1.7 mm (LACM 72-12 and LACM 72-59); C: protoconch, same shell as B; D, E: detail of the microsculpture, same shell as A.

Figura 31. Haplocochlias erici *(Strong & Hertlein, 1939). A, B: conchas, diámetro 2,45 mm y 1,7 mm (LACM 72-12 and LACM 72-59); C: protoconcha, misma concha que B; D, E: detalles de la microescultura, misma concha que A.*

still larger cords with fine intercalary threads; axial sculpture of fine, close-spaced riblets in the interspaces between the spiral threads over the entire surface; periphery of last whorl and base well rounded, umbilicus narrow, with a deep groove between the inner lip and the last spiral cord; aperture circular, the posterior angle falling low on the body whorl; outer lip thick, smooth; inner lip thin where it borders the umbilicus, spreading above. Operculum unknown".

Shell of small size, robust, turbiniform, spire formed by 4 whorls of rapid growth, separated by a deep suture. The protoconch is $^{3}/_{4}$ of whorl, smooth and measures 170 μm. The teleoconch has 3 ¼ whorls, in apertural view are observed in the 1st and 2nd whorls 4 spiral cords and 16 on the last one. In the first whorl, the spiral cords stretch in zig-zag and cross with axial striae forming hexagonal cells. Ornamentation formed by prominent spiral cords, narrower than their interspaces; axial striae which are transformed into lamellae that occupy the spaces between cords, also with micro tubercles.

Aperture rounded, peristome continuous; columella thick, not reflected, widened at its base where is observed a triangular depression at the junction with outer lip and the umbilical cord; outer lip thick, margin crenulated and contour slightly angled by the presence of spiral cords. Umbilicus variable depending on the H/D parameter of each shell.

Dimensions: The type measures: diameter, 2.0 mm; height, 1.3 mm.

The photographed specimens measure: 2.28 mm in height and 2.45 mm in diameter (H/D: 0.93); 1.95 mm in height and 1.75 mm in diameter (H/D: 1.11).

Habitat: From 5 to 16 m (Strong & Hertlein, 1939); 10 to 50 m (Keen, 1971).

Distribution: Bahía Honda, Pacific coast of Panama (Strong & Hertlein, 1939); Guaymas, Mexico to Gorgona Island, Pacific coast of Colombia (Keen, 1971).

Remarks: In size and shape this species is very similar to the last ones, but the lack of prominent spiral sculpture makes it entirely different from any other species described from the Pacific coast.

The shells with H/D: 0.93 present a much more open umbilicus with 4 cordlets inside, besides growth lines. Shells with H/D: 1.11 present a narrower umbilicus and the inner cordlets are scarcely visible.

Haplocochlias concepcionensis (Lowe, 1935) (Figure 32)

? *Homalopoma concepcionensis* Lowe, 1935. *Transactions of the San Diego Society of Natural History*, 8 (6): 24, pl. 4 fig.3. [Type locality: Concepción Bay, Baja California, Mexico].

Parviturbo concepcionensis (Lowe, 1935): Keen, 1971. *Sea Shells of Tropical West America*: 345, fig. 122.

Type material: Holotype in Lowe collection in SDSNH (11593).

Material examined: Mexico: 2 s, E of Isla Willard, Bahía San Luis Gonzaga, Baja California, 18-27 m, sand bottom (LACM 69-25); 14 s, 1 mile off Olas Altas, Mazatlan, Sinaloa, 18 m; 7 s, Bahía San Carlos, Guaymas, Sonora, 31.1 m (LACM 178541); Panama, Pacific coast: 2 s, Venado Island, Canal Zone, intertidal (LACM 70-15); 7 s, Palo Seco, Canal Zone, intertidal, upper and middle zones (LACM 72-74).

Description: Original description in Lowe (1935): *"Shell small, pure white, solid, globose, suture strongly appressed; five whorls, including the smooth nucleus, strongly tabulated by a peripheral keel. On the penultimate whorl is a strong sutural keel and two almost equally strong just below it; on the flat shoulder just anterior to the major keel are three secondary flat spiral cords with wide interspaces. On the body whorl, just below the suture, are two major spiral cords with a secondary spiral thread*

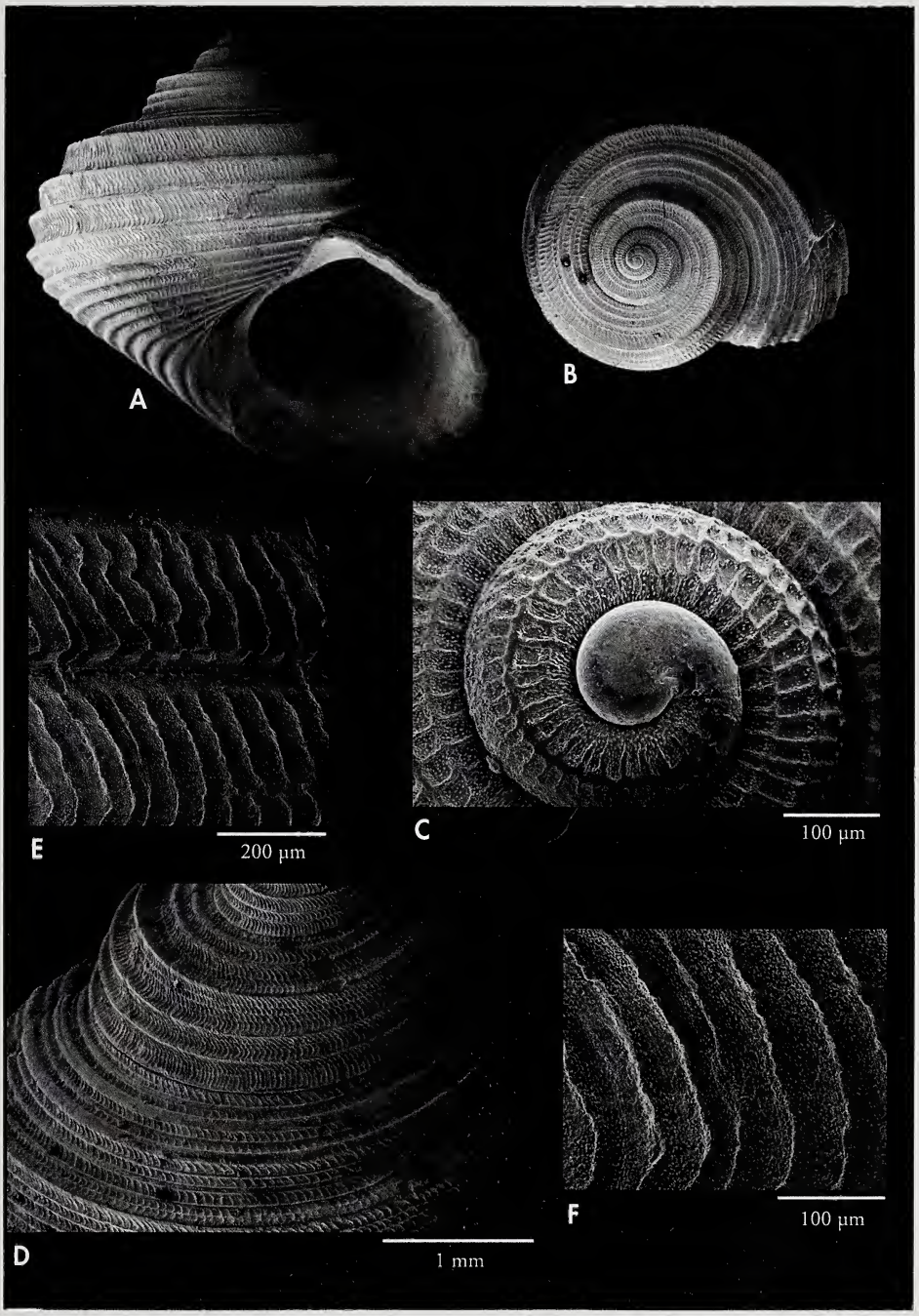

Figure 32. *Haplocochlias concepcionensis* (Lowe, 1935). A, B: shells, 4.6 and 3.1 mm, San Carlos Bay, Guaymas, Sonora, Mexico (LACM 178541); C: protoconch of Fig. B; E, F: sculpture and detail, same shell as A.

Figura 32. Haplocochlias concepcionensis *(Lowe, 1935). A, B: conchas, 4,6 y 3,1 mm, Bahía San Carlos, Guaymas, Sonora, Mexico (LACM 178541); C: protoconcha, misma concha que B; E, F: microescultura y detalle, misma concha que A.*

between; next three of the strong cords with four spiral threads anterior to each; posterior to the last are thirteen flattened spiral cords of about equal strength and equal interspaces. The entire surface between the spiral sculpture is covered with microscopic, diagonally radial striae. Aperture circular, outer lip thin; heavy callus on the columella, back of which is a large, flattened chink with four radial threads on its flat surface. Diameter 5.6 mm, altitude 5.6 mm".

Shell large, almost as high as wide (HD: 0.90), turbiniform, robust, spire formed by slightly more than 5 whorls increasing rapidly, separated by a deep suture. The protoconch has ¾ of whorl, completely smooth and measuring 180 μm in diameter. The teleoconch has 4 ¼ to 4 ½ whorls. Typical ornamentation formed by spiral cords, axial striae and micro tubercles. In apertural view 4 spiral cords are observed in the first whorl, 5 in the second, 6 in the third and 17 at the last one, of which the two upper ones, subsutural, are smaller in size; from the 3rd to 6th, peripheral cords are more prominent, spaced and angle the shell; the remaining, basal, are rounded, regular in size, as wide as their interspaces.

Aperture oval, prosocline; parietal area with a thin callous layer; columella arched, widened towards the base in which a little deep depression is observed; outer lip not very thick, reflected, edge sharpening and finely crenulated. Umbilicus narrow, deep, delimited by a not very thick spiral cord, inside a spiral cordlet is observed.

Habitat: Collected from the intertidal to 28 m.

Distribution: Head of the Gulf of California to Panama (Keen, 1971; Abbott, 1974).

Remarks: Described by Lowe (1935) in the genus *Homalopoma*, but expressing some doubts about its generic placement: *"As there was no sign of an operculum attached to the animal, I am in doubt whether to place the species in* Homalopoma *or* Liotia".

Keen (1971) places *Homalopoma concepcionensis* Lowe, 1935 in *Parviturbo*, along with other species described previously in *Liotia*. However, in our opinion, *H. concepcionensis* has all those characters described for *Haplocochlias*, and no those of *Parviturbo* mentioned in the introduction; so we decided to place the species in this genus.

Haplocochlias francesae (Pilsbry & McGinty, 1945) (Figure 33)

Parviturbo francesae Pilsbry & McGinty, 1945. *The Nautilus*, 59: 56, pl. 6, fig. 6. [Type locality: Off Palm Beach, Florida, USA].

Type material: Holotype in ANSP (181316) examined on photograph; paratypes in McGinty collection at MCZ (226843 and 207086), examined.

Material examined: USA, Florida: 1 s, Off Palm Beach, 91 m, paratype, McGinty collection (MZC 226843); 1 s, Palm Beach, paratype, McGinty collection (MZC 207086); 1 s, SW Florida (26° 52.36′ N – 83° 27.22′ W), dredged in 54 m (CEG); 2 s, off Sombrero Light, Kay Vaca, Monroe Co., dredged 60 m (CHL); 4 s, off Cedar Kays, Levy Co., dredged 54 m (CHL); 24 s, Monroe County, Key Colony Beach transect, 24° 39′ 04″N, 080° 59′ 16″W, 36 m (FMNH 328629); 3 s, Monroe County, Dry Tortugas transect, 24° 28′ 52″N, 082° 56′ 59″W, 34 m (FMNH 328629); 3 s, Monroe County, off Looe Key, 24° 31′ 20″N, 081° 25′ 55″W, 53-54 m (FMNH 328725); 1 s, Monroe County, Infaunal Mollusk Survey, Marquesas transect, 24° 23′ 33″N, 082° 27′ 59″W, 49 m (FMNH 333876); 4 s, Monroe County, Windley Key transect, 24° 53′ 35″N, 080° 31′ 47″W, 39 m (FMNH 333874); 1 s, Monroe County, Ramrod Key transect, 24° 35′ 20″N, 081° 25′ 56″W, 7 m (FMNH 333873); 6 s, Monroe County, Ramrod Key transect, 24° 31′ 35″N, 081° 25′ 56″W, 43 m (FMNH 333774); 1 s, Monroe County, SW corner of Looe Key National Marine Sanctuary, 24° 31′ 56″N, 081° 25′ 55″W, 36 m (FMNH 332030); 1 s, Monroe County, Ramrod Key transect, off Looe Key, 24° 32′ 14″N, 081° 25′ 56″W, 33-36 m (FMNH 333873); 1 s, Monroe County, Sand Key transect, 24° 25′ 56″N, 081° 53′ 19″W, 53 m (FMNH 333873); 15 s, Monroe County, Carysfort Reef transect, 25° 13′ 23″N, 080° 11′ 24″W, 53 m (FMNH 328625); 1 s, Monroe County, Key Colony Beach transect, 24° 38′ 22″N, 080° 59′ 01″W, 57 m (FMNH 333905); 1 s, Monroe County, Ramrod Key transect, 24° 31′ 56″N, 081° 25′ 55″W, 35 m (FMNH 333913); 1 s,

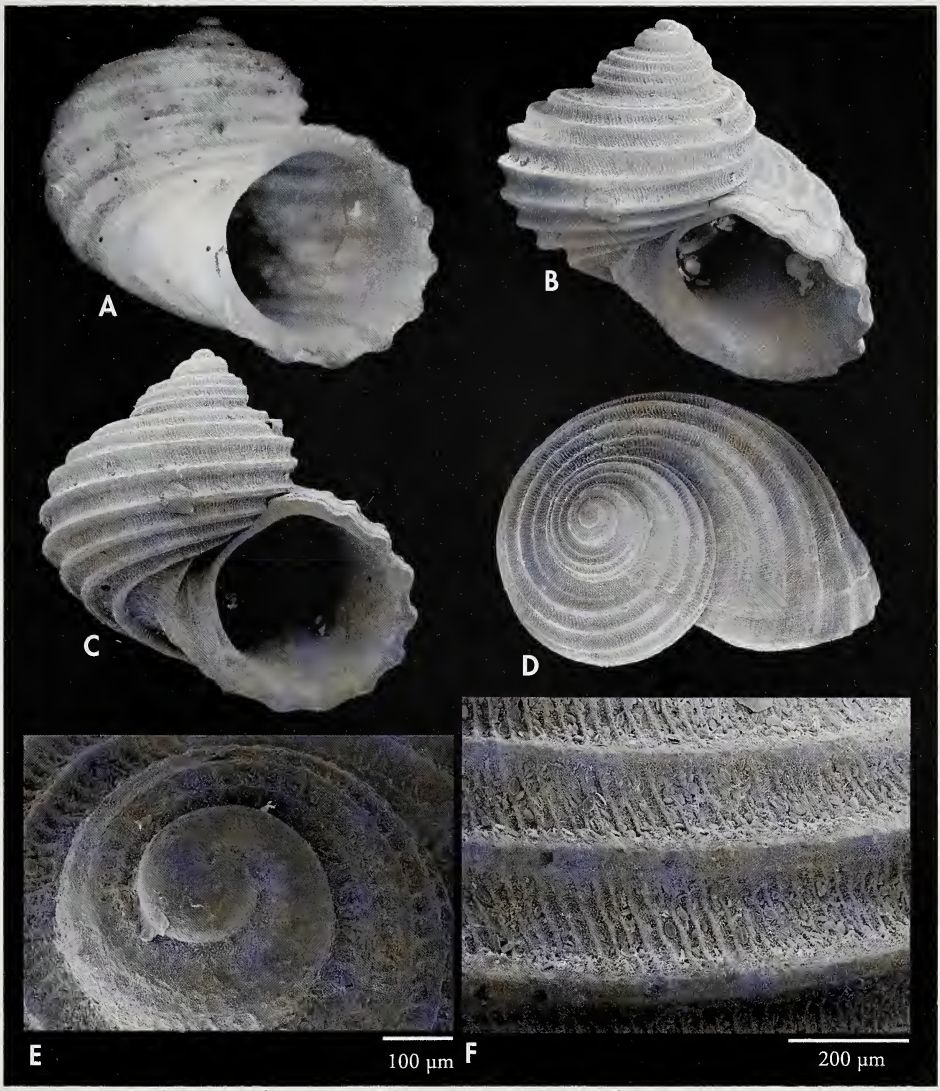

Figure 33. *Haplocochlias francesae* (Pilsbry & McGinty, 1945). A: holotype, height 3.15 mm (ANSP 181316); B-D: shell, 3.06 mm, SW Florida (26° 52.36' N – 83° 27.22' W) (CEG); E: protoconch, same shell as D; F: microsculpture of the last whorl.

Figura 33. Haplocochlias francesae *(Pilsbry & McGinty, 1945). A: holotipo, altura 3,15 mm (ANSP 181316); B-D: concha, 3,06 mm, SO Florida (26° 52,36' N – 83° 27,22' W) (CEG); E: protoconcha, misma concha que D; F: microescultura de la última vuelta.*

Monroe County, off Halfmoon Shoal, 24° 35′ 20″N, 081° 25′ 56″W, 50 m (FMNH 328621); 1 s, Monroe County, Key Colony Beach transect, 24° 38′ 00″N, 080° 58′ 54″W, 69 m (FMNH 333906); 2 s, Monroe County, off Halfmoon Shoal transect, 24° 23′ 16″N, 082° 28′ 08″W, 49-50 m (FMNH 333873); 5 s, Monroe County, Carysfort Reef transect, 25° 12′ 55″N, 080° 10′ 38″W, 79 m (FMNH 333873); 3 s, Key Colony Beach transect, 24° 42′ 14″N, 081° 00′ 14″W, 72 m (FMNH 328626).

Description: The original description in PILSBRY & MCGINTY (1945: 56) is as follows: "*The moderately solid but not thick white shell is broadly turbinate, with somewhat elevated but short spire, rounded periphery and narrow umbilicus, and with sculpture of strong spiral cords, nine on the last whorl. There are 4 ½ strongly convex whorls, with deep suture. The first whorl is smooth; the next (or first post nuclear whorl) has 3 or 4 spiral cords crossed by delicate axial threads. The last whorl has nine strong spiral cords, the upper one somewhat smaller, the lower or ninth cord bordering the umbilicus. The cords are separated by decidedly wider intervals, which are closely sculptured across by delicate axial threads. The umbilicus is narrow and deep, its walls smooth within. The aperture is subcircular, peristome somewhat thickened within, continuous, with scalloped outer margin. Diameter 3.4 mm, height: 3.15 mm.*"

Protoconch smooth of just ¾ of whorl and about 290 μm in diameter. Spaces between the cords with axial threads, more distant in the first two whorls of the teleoconch forming quadrangular cells and much more tight and numerous in last whorl and a half as lamellae. Spaces between axial threads are covered by microtubercles. At the base of the columella, the point of contact with the periumbilical cord forms a slightly depressed area.

Dimensions: The shell examined measures 2.93 mm in height and 3.06 mm diameter (H/D: 0.96).

Habitat: A circalittoral species, its bathymetric range is between 54 and 91 m deep.

Distribution: Limited to East and West Florida, USA. Recorded from off Palm Beach (PILSBRY & MCGINTY, 1945); southwest of Johns Pass, West Florida (ABBOTT, 1974).

Remarks: The scalloped outer lip, the number of spiral cords and the axial striae forming fine lamellae characterize this species and distinguish it from its congeners.

PILSBRY & MCGINTY (1945) comment: "*This is a broader shell than* C. *[error for* Parviturbo*]* weberi *with narrower umbilicus, and having exceptionally delicate and beautiful sculpture in the intervals of the spiral cords. The projecting embryonic shell of only one whorl, or at most one and one-fourth, is also characteristic*".

Haplocochlias francesae is a species that in the adult stage cannot be mistaken in its determination. However, immature stages can be confused with *H. calidimaris* and vice versa. *Haplocochlias francesae*, contrary to *H. calidimaris*, has a smooth protoconch; the number of spiral cords remains unchanged, not being doubled in the latest half whorl; but above all, its axial striation, enhanced by the number and proximity of fine lamellae is one of the morphological characters which most helps for their differentiation.

Haplocochlias panamensis spec. nov. (Figure 34)

Type material: Holotype in MNCN (15.05/60046).
Type locality: Coiba Island, Pacific coast of Panama.
Etymology: The specific name indicates the country where the species was collected.

Description: Shell small, almost as high as wide, very solid, of turbiniform aspect, spire formed by five rapidly expanding whorls separated by a deep suture. Protoconch ¾ whorl, apparently smooth and measuring about 230 μm in maximum diameter. Teleoconch formed by 4 ¼ whorls; the ornamentation is formed by spiral cords and axial striae with microtubercles in the interspaces between cords. On the first whorl 4-5 spiral cords can be seen; on the last there are 28-29 strong spiral cords, three of which (the 5th, close to the suture, and the 9th and 12th, peripheral) form angles at the periphery of the shell. The spaces between cords are slightly concave, within there are very numerous axial lamellae, after the first teleoconch whorl they become very numer-

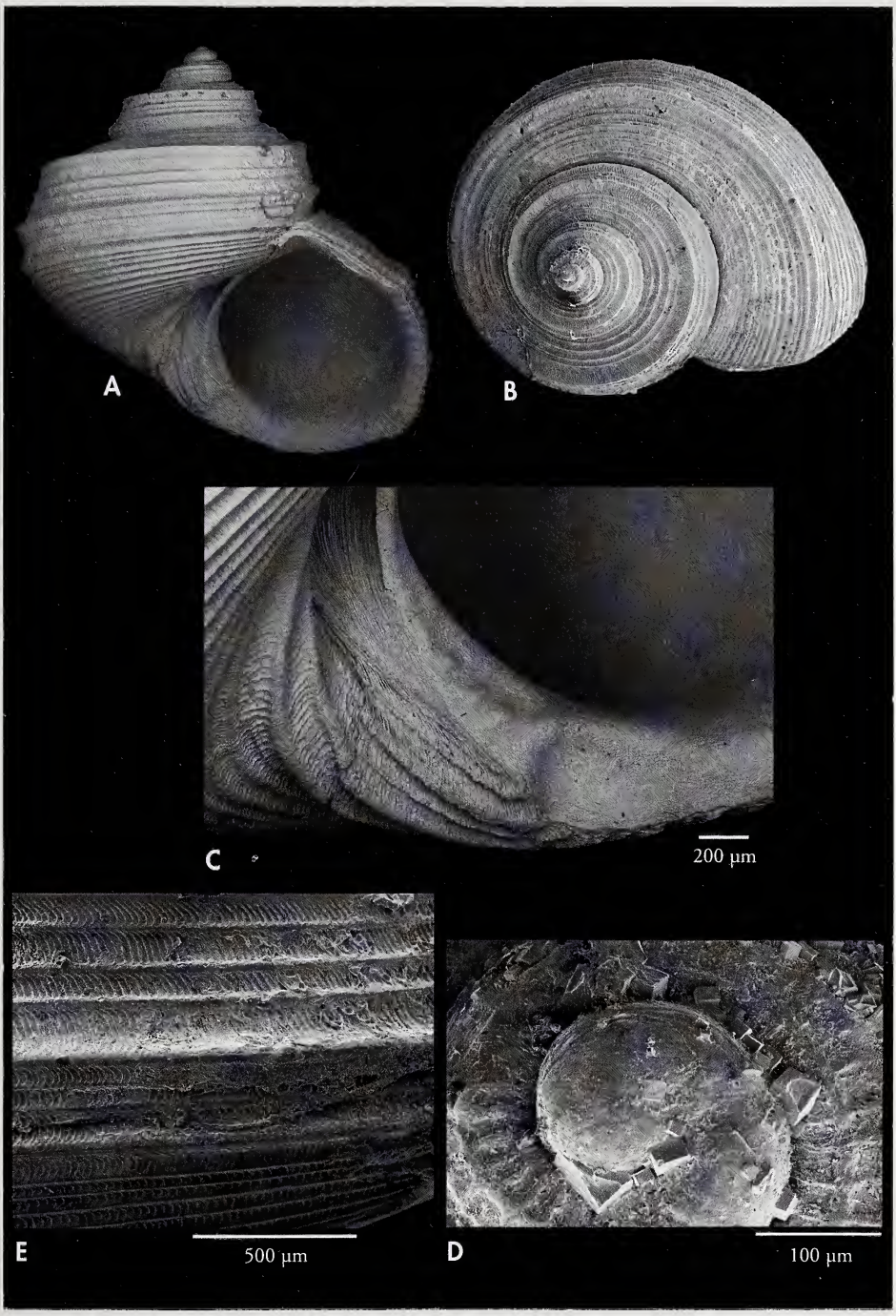

Figure 34. *Haplocochlias panamensis* spec. nov. A, B: holotype, diameter 4.18 mm (MNCN); C: detail of the umbilicus; D: protoconch of the holotype; E: microsculpture and detail of the last whorl.

Figura 34. Haplocochlias panamensis *spec. nov. A, B: holotipo, diámetro 4,18 mm (MNCN); C: detalle del ombligo; D: protoconcha del holotipo; E: microescultura y detalle de la última vuelta.*

ous and more crowded; the spaces between them are occupied by microtubercles. Aperture ovoid, prosocline; peristome continuous. Outer lip very thick, slightly modified by the presence of spiral cords, on the inner aspect are numerous elongate denticles that become wider as they proceed to the columella. Parietal area covered by a thin callous coat. Columella very arched, widened basally, showing 3-4 small denticles and a quadrangular space at the convergence of the umbilical cord, the columella and the outer lip. Umbilicus partially occluded by the basal enlargement of the columella and the presence of several strong cords; under high magnification 2-3 fine spiral threads can be seen within.

Dimensions: the holotype measures 3.78 mm in height and 4.18 mm in diameter (H/D: 0.90).

Habitat: Species collected in dredgings at 200 m in depth on the continental slope.

Distribution: Only known from Coiba Island, Pacific coast of Panama.

Remarks: *Haplocochlias* spec. nov. differs from the remaining species of the group, by its three keels which angulate the periphery; by the denticulation of the lip and most notably, the denticulation of the columella, a condition not observed in any other species of the genus.

The most similar species is *Haplocochlias pacorubioi* spec. nov., but it lacks the quadrangular depression and the denticulation in the columella.

Haplocochlias sp. (Figure 35)

Material examined: 1 s, Caribbean coast of Panama (CFR).

Description: Shell of small size, strong, compact, turbiniform, spire formed by 5 rapidly expanding whorls, tricarinate, separated by a marked suture. The protoconch is apparently smooth, has ¾ whorl and measures 230 μm. The teleoconch has 4 ¼ whorls which are totally covered by spiral cords, their interspaces covered by axial grooves and microtubercles. Spiral cords are distributed thus: 4-5 on the first whorl, 5 on the second, 8-9 on the third and 35 on the last. The cords are of regular size, except the 8th, the 14th and the 17th, which are more prominent and angle the periphery of the shell, giving a tricarinate aspect. After the first teleoconch whorl the axial striae become more numerous and crowded. Aperture ovoid; outer lip thick, externally finely crenulated, inside within having thin and elongated spiral denticles. The columella is shorter that its congener from Coiba Island and it has no clearly triangular area characteristic of the group, although an angulation is formed at the convergence of the outer lip, columella and periumbilical cord. Umbilicus partially occluded, deep, with 1-2 spiral cordlets visible within.

Dimensions: 3.9 mm in height and 4.2 in diameter (H/D: 0.89).

Habitat: Unknown. Probably in shallow water.

Distribution: Only known from Caribbean coast of Panama.

Remarks: *Haplocochlias* sp. 1 is very similar to *H. panamensis*, with three very thick cords that form angles on the periphery of the shell, however, the distribution of the cords on the teleoconch is more regular. *H. panamense* has more irregular cords on the teleoconch, fewer spiral cords and a narrower umbilicus.

An important fact is that the specimens of *H. panamensis* and *Haplocochlias* sp. studied here originated on opposite sides of the Panama isthmus; *H. panamensis* comes from Coiba Island, Pacific coast of Panama, and *Haplocochlias* sp. from the Caribbean coast of Panama. Despite the conchological similarities between these two taxa, they are treated as distinct based in part on zoogeography.

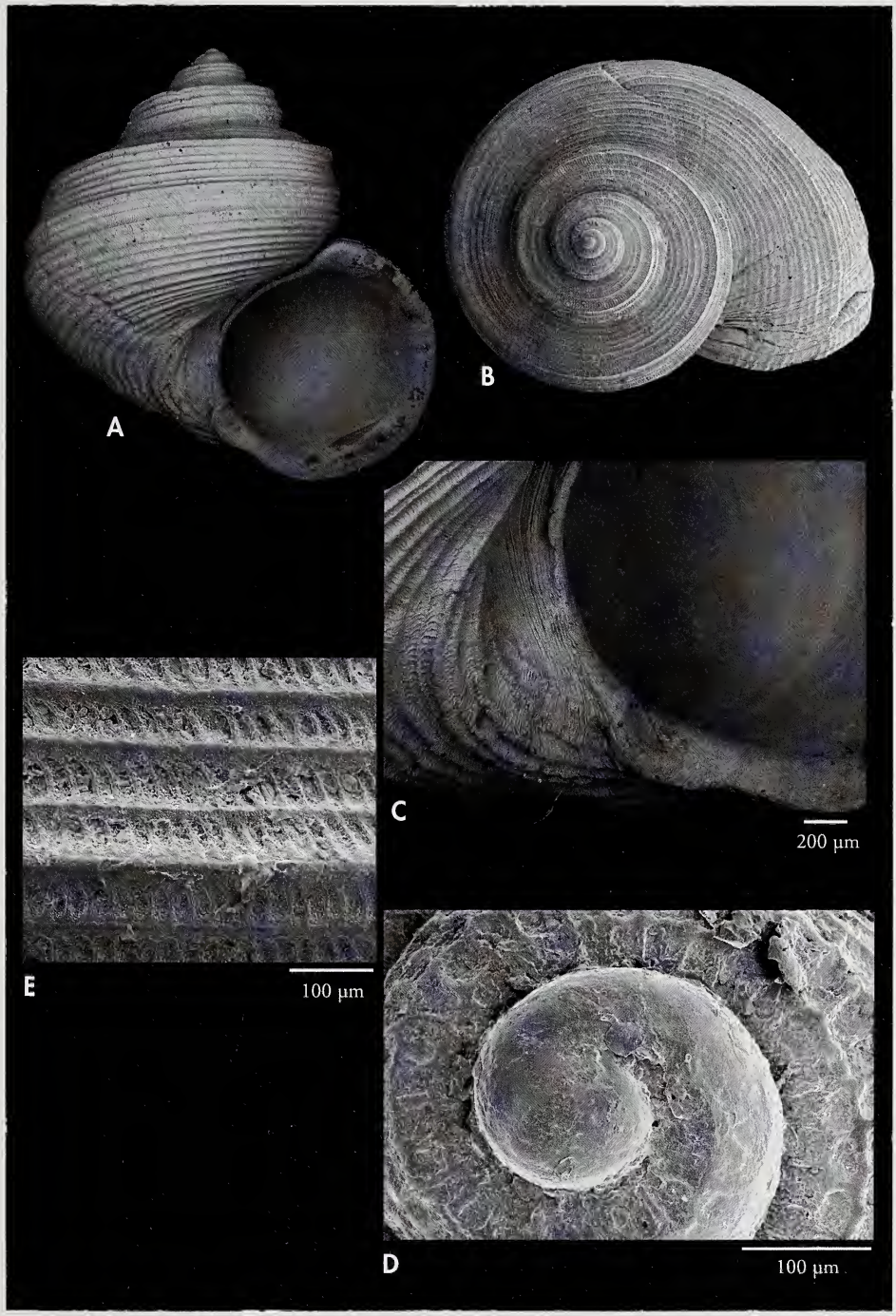

Figure 35. *Haplocochlias* sp. A, B: shell, diameter 4.20 mm (CFR); C: protoconch of the same shell; D: microsculpture of the last whorl.

Figura 35. Haplocochlias *sp. A, B: concha, diámetro 4,20 mm (CFR); C: protoconcha de la misma concha; D: microescultura de la última vuelta.*

Haplocochlias turbinus (Dall, 1889) (Figure 36)

Cyclostrema turbinum Dall, 1889. *Bulletin of the Museum of Comparative Zoology* 18: 393-394, pl. 33, fig. 6 [not 5 as erroneously referred in the text]. [Type locality: Off Havana, Cuba, 80 fathoms (146 m)].
Parviturbo turbinum (Dall, 1889): Pilsbry & McGinty, 1945.

Type material: Holotype in USNM (214278). Examined by SEM.
Other material examined: None.

Description: Original description in Dall (1889): "*Shell small, thin, subconic, with four rounded whorls and a minute glassy nucleus; radiating sculpture of fine oblique incremental lines, which on the early whorls rise into very fine threads, visible crossing the interspaces of the spiral sculpture; spiral sculpture of (on the last whorl) about seven strong smooth even cinguli on the top of the whorl, and fourteen or fifteen more rather smaller from the periphery to the brink of the umbilicus; there are also a few finer ones, especially three near the suture, and occasionally some spiral striation faintly indicated; on the top of the whorl the interspaces are about twice as wide as the threads, but not so wide on the base. The whorls, periphery, and base are evenly rounded, the suture distinct, not channelled; the umbilicus perforate, with smoothish walls; aperture half as high as the shell, oblique, nearly circular, with sharp, simple, slightly expanded edges. Max. diam.* 3.25; alt. 2.75 mm.".

Dimensions: The holotype, on the photograph received from the USNM with scale, is 3.0 x 3.0 mm).

The shell has a turbiniform shape, it is somewhat robust and its spire is formed by 4 whorls, of which ¾ correspond to the protoconch and 3 ¼ to the teleoconch; its periphery is rounded and on it neither a keel nor thickened cords can be seen. The protoconch measures 240 μm, and, due to its deteriorated state we have not observed if it is smooth or has spiral cordlets. The teleoconch is decorated with spiral cords and axial striae in their interspaces. There are 3-4 spiral cords on the first whorl, 4 on the second, and 24 on the last one; the cords are usually narrower than their interspaces. Aperture rounded; outer lip thickened, apparently not crenulated on its external border or denticulate within; columella thick, slightly arched and reflected towards the umbilicus without occluding it. At the confluence of the outer lip, columella and periumbilical cord, a triangular area is formed which characterizes the species. Just before the outer lip of the last whorl a thickening is present (as seen in some other species of *Haplocochlias*). Umbilicus narrow and deep, 2 cordlets are visible within.

Habitat: Species collected by dredging in deep circalittoral waters and on the continental slope. Dall (1889) records it at 146 m (80 fathoms) in depth.

Distribution: USA: North Carolina (Dall, 1889; Porter, 1974); Cuba: North Havana Province (Pilsbry & McGinty, 1945). Range: 34.2°N to 23°N; 82°W to 76.5°W.

Remarks: Originally described by Dall (1889) in the genus *Cyclostrema*, later transferred to *Parviturbo* by Pilsbry & McGinty (1945), indicating only: "*apparently belongs here*". In our opinion, *Cyclostrema turbinum* belongs to the genus *Haplocochlias*, if we take into account the general shape of the shell, the ornamentation consisting of many spiral cords and axial striae covering their interspaces and especially the triangular area formed at the convergence of the outer lip, columella, and periumbilical cord.

ungrouped

The species that follow are not grouped with any of the preceding taxa because each has characters which differ sufficiently from one another as well as from the preceding grouped species.

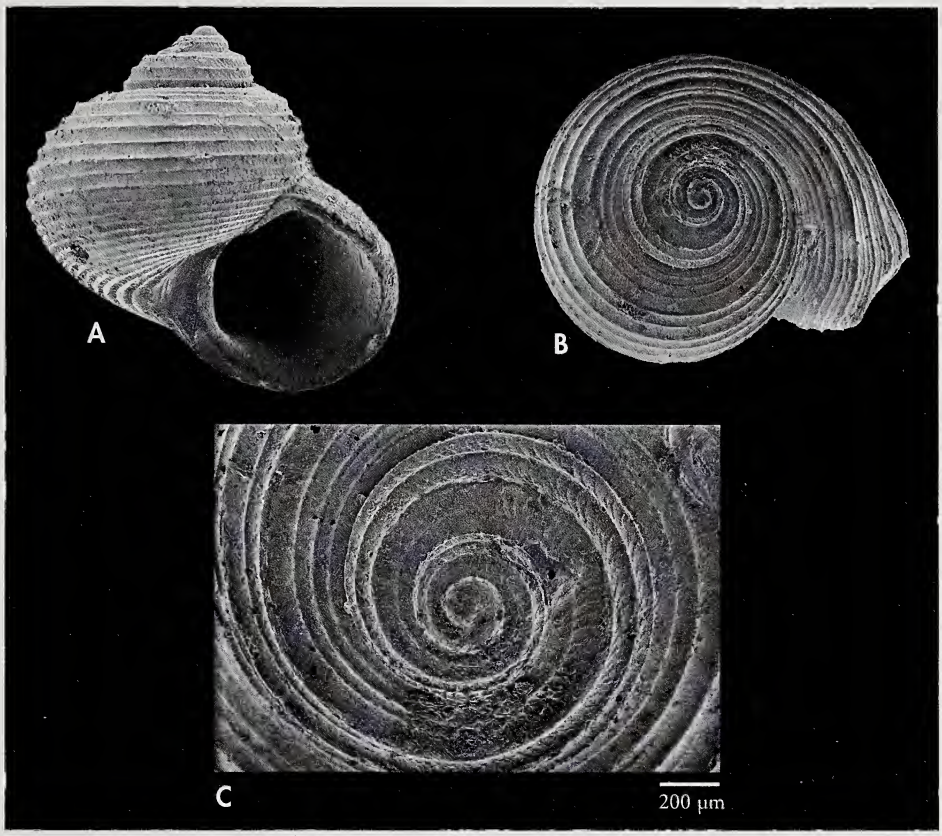

Figure 36. *Haplocochlias turbinus* (Dall, 1889). A, B: holotype, diameter 3.0 mm (USNM - 214278); C: apical view.
Figura 36. Haplocochlias turbinus *(Dall, 1889). A, B: holotipo, diámetro 3,0 mm (USNM - 214278); C: vista apical.*

Haplocochlias pauciliratus spec. nov. Rubio, Rolán & Lee (Figures 37, 38)

Type material: Holotype in FLMNH (457009) (Fig. 37A). Paratypes in MNCN (1 s, 15.05/60042), MHNS (1 s, 100573), MCZ (1 s) and CHL (1 s) from Gibbons Bay, Hamilton, Bermuda.
Other material examined: Bermuda: 16 s, from Gibbons Bay, Hamilton, Bermuda, shore drift (CHL).
Type locality: Mt. Olympus Reef, 12 miles NNW of West End, Grand Bahama Island, Bahamas.
Etymology: The specific name alludes to the scarcity of spiral cords.

Description: Shell very small, almost as high as wide, solid, turbiniform, spire formed by 3 rapidly-expanding whorls, separated by a wide and deep suture, which on the last whorl is further widened and separates from the preceding whorl. The protoconch has ¾ whorl, totally smooth and 250 µm in maximum diameter. Teleoconch formed by 2 ¼ - 2 ¾ whorls; ornamentation typical, formed by spiral cords, axial striae, and microtubercles in the spaces between cords. On the last whorl 11-12 spiral cords can be seen, usually wide and prominent, except a few which are finer and intercalated in the subsutural and dorsal areas. Aperture rounded, prosocline; peristome continuous. outer lip modified by the presence of spiral cords, not widened or crenulated

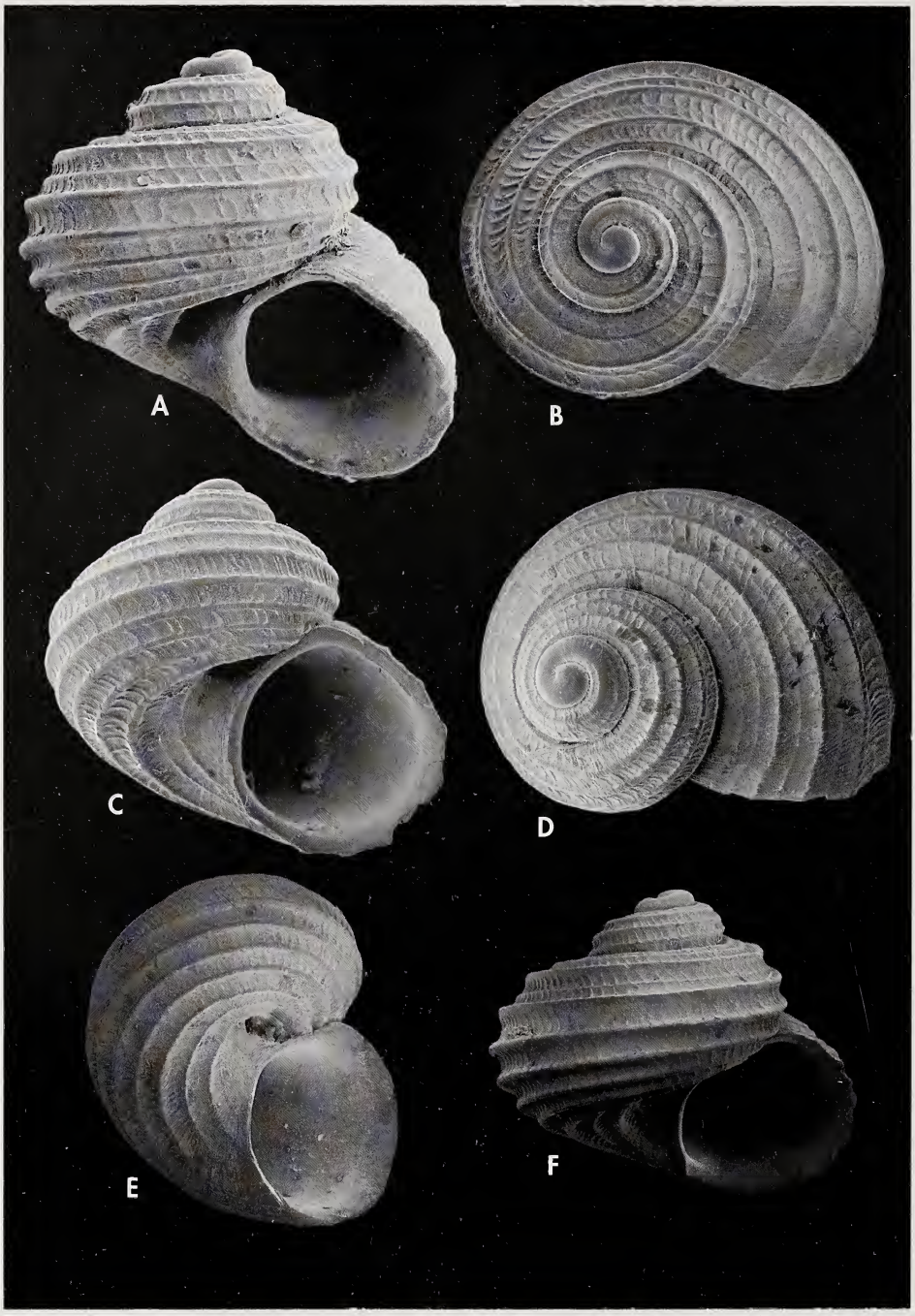

Figure 37. *Haplocochlias pauciliratus* spec. nov. A, B: holotype, 1.5 mm, Mt. Olympus Reef, 12 miles NNW of West End, Bahamas (FLMNH, *ex* CHL). C-F: paratypes, all from Gibbons Bay, Bermuda; C: 1.3 mm (MNCN); D: 1.36 mm (MHNS); E, F: 1.2 mm (the same shell) (CHL).
Figura 37. Haplocochlias pauciliratus *spec. nov. A, B: holotipo, 1,5 mm, Mt. Olympus Reef, 12 millas NNO de West End, Bahamas (FMNH, ex CHL). C-F: paratipos de Gibbons Bay, Bermuda; C: 1,3 mm (MNCN); D: 1,36 mm (MHNS); E, F: 1,2 mm (la misma concha) (CHL).*

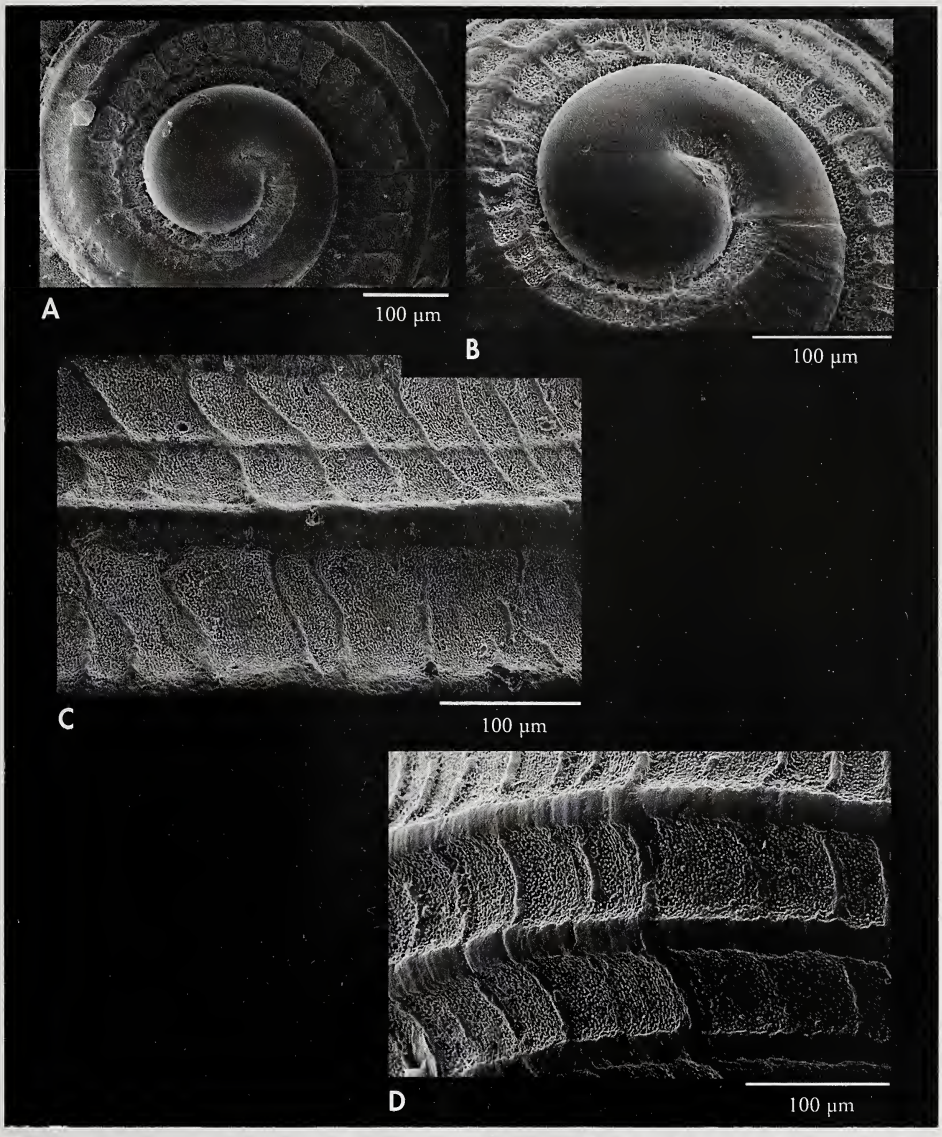

Figure 38. *Haplocochlias pauciliratus* spec. nov. A: protoconch of the holotype. B: protoconch of the paratype of Fig. 37D, Bermuda; C: microsculpture of the last whorl of the holotype; D: microsculpture of the last whorl of the paratype of Figure 37C, from Bermuda.

Figura 38. Haplocochlias pauciliratus *spec. nov. A: protoconcha del holotipo. B: protoconcha del paratipo de la Fig. 37D, Bermudas; C: microescultura de la última vuelta del holotipo; D: microescultura de la última vuelta del paratipo de la Figura 37C, Bermudas.*

within; columella arched, reflected externally. Umbilicus relatively wide and deep, delimited by a strong cord, two fine spiral cordlets and feeble growth lines within.

Dimensions: The holotype measures 1.47 mm in height and 1.5 mm in diameter.

Habitat: An infralittoral species which in the Bahamas was found on

sandy bottom with fragments of coralline algae.

Distribution: Only known from NNW West End, Grand Bahama and Gibbons Bay, Bermuda.

Remarks: *Haplocochlias pauciliratus* spec. nov. differs from the other species in the genus, particularly from those with a smooth protoconch by the reduced number of spiral cords, their thickness and regularity, as well as the H/D ratio very close to 1.

We have only been able to examine one shell (the holotype) from Bahamas, and its morphological characters are almost identical to the shells from Bermuda. Only slight differences in their morphology can be observed and we believe these fall within normal intraspecific variability.

An unusual feature in the ornamentation of this species is that the axial striae maintain a certain regularity in their separation throughout the teleoconch. Only between the basal cords do the striae appear closer.

Haplocochlias pauciliratus is a species which by its morphological characteristics (shape of the protoconch, shorter spire and shape of the umbilicus) is excluded from the preceding groups. It is close to the genus *Parviturbo* Pilsbry & McGinty, 1945. However, its general appearance, shape and regularity of the axial grooves, and the shape of the outer lip have convinced us to place it in *Haplococlias*.

It can be distinguished from the fossil species *H. chipolanum* (Fig. 42G) because it has a higher number of spiral cords, the periumbilical cord is not so marked and the external lip has a simple margin, not scalloped, scarcely reflected outwards.

Haplocochlias bellus (Dall, 1889) (Figures 39-41)

Fossarus (Gottoina) bella Dall, 1889. *Bulletin of the Museum of Comparative Zoology*, 18: 272-273, pl. 28, fig. 10. [Type Locality: Sand Key, Florida, USA].

Type material: Holotype in MCZ (7461), examined.
Other material examined: USA, Florida: 3 s, station BIERFK-421, Carysfort Reef, Florida Keys, Monroe Co., 104 m (FMNH, 328628); 1 s, station BIERFK-447, Key Colony Beach, Florida Keys, Monroe Co., 77 m (FMNH, 333882).

Description: Original description in Dall (1889): "*Shell small, white, solid, shaped much like* Littorina littorea, *having four and a half whorls and a minute glassy rounded nucleus. Radiating sculpture consisting of fine incremental striae and occasional irregularities of growth. Spiral sculpture of two sorts; 1st, fine spiral grooving covering the whole shell evenly and always present; 2d, strong spiral ridges, generally nine or ten on the last whorl, but sometimes smaller and more numerous, sometimes partly absent, sometimes so arranged as to tabulate the part of the whorl next the suture, and almost invariably smaller and weaker as they approach the base and the centre of the base. Suture distinct, not channelled; aperture simple, nearly circular, but the outer margin of its thickened edge angulated at the junction with the body; callus continuous; columella arched, with a small chink, but no umbilicus behind it; this chink varies in size with different specimens. Aperture oblique, its upper margin a little depressed. Alt. 3.5 mm; max. diam. 3.5 mm*".

Shell robust, as high as wide (HD: 1.00), spire formed by 4 ½ whorls of rapid growth. The protoconch has a little more than ¾ whorl, it is completely smooth and measures about 270 μm. The teleoconch has 3 ¾ whorl; it is ornamented with thick spiral, very prominent, cords that are duplicated and others, finer, located in the spaces between them; some marked growth lines, axial grooves in the interspaces of the first two whorls and micro tubercles all along the shell can also be observed. Taking the holotype in apertural view,

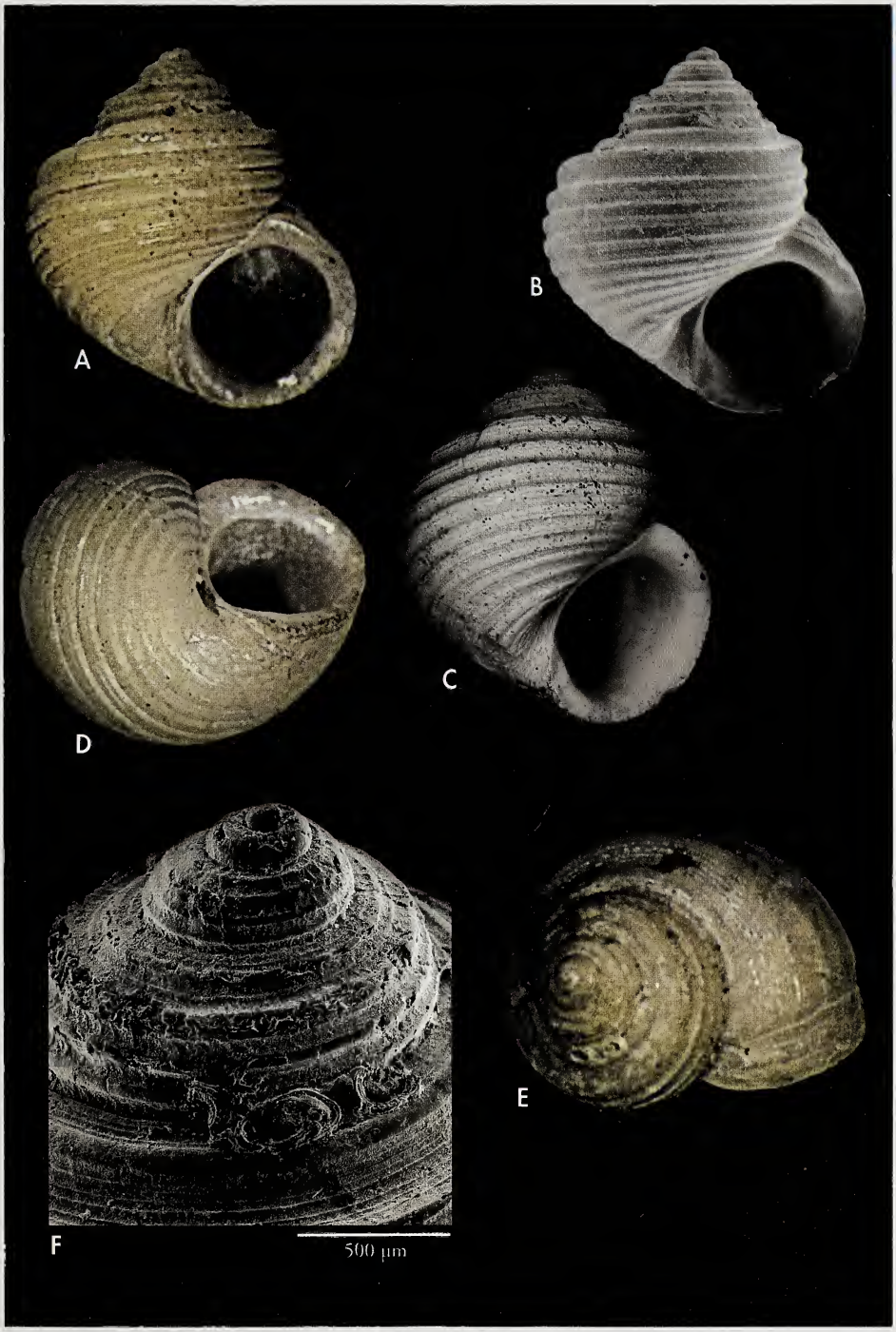

Figure 39A-C. *Haplocochlias bellus* (Dall, 1889). A-E: holotype, 3.5 mm, (MCZ); F: apex of the holotype.

Figura 39A-C. Haplocochlias bellus (*Dall, 1889). A-E: holotipo, 3,5 mm, (MCZ); F: ápice del holotipo.

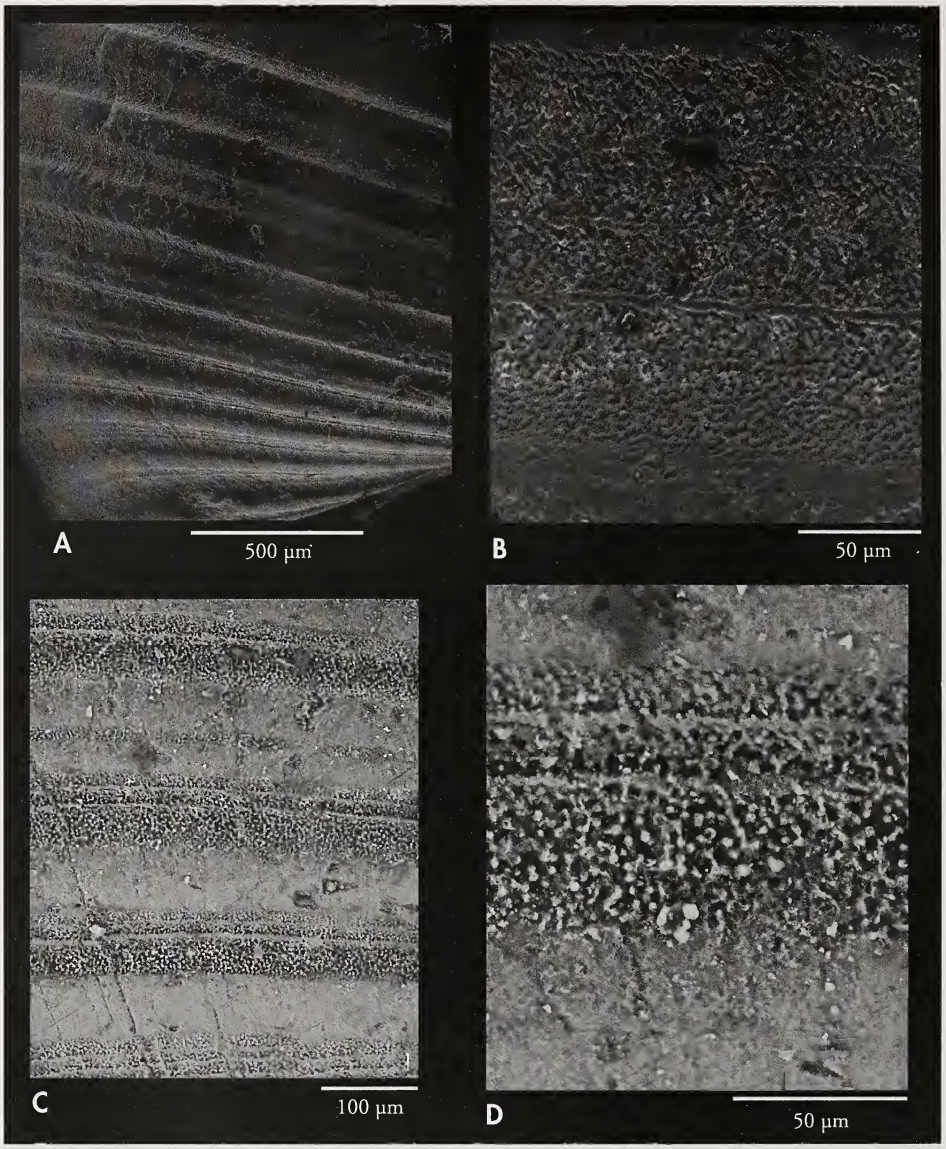

Figure 40. *Haplocochlias bellus* (Dall, 1889), sculpture and micro sculpture of the last whorl of the holotype.

Figura 40. Haplocochlias bellus *(Dall, 1889), escultura y microescultura de la última vuelta del holotipo.*

we can see 3 cords in the first whorl of the teleoconch, 4-5 in the second and 12 strong cords, some duplicated, on the last; in addition, numerous very fine spiral striae can be seen in the interspaces. The non adult specimen photographed (Fig. 41A), shows us a very wide columella on its base, with a broad triangular depression in the area of intersection with the periumbilical cord; an external lip not widened and sharply scalloped at its margin. In the holotype, single adult specimen examined, the umbilicus is almost hidden by the

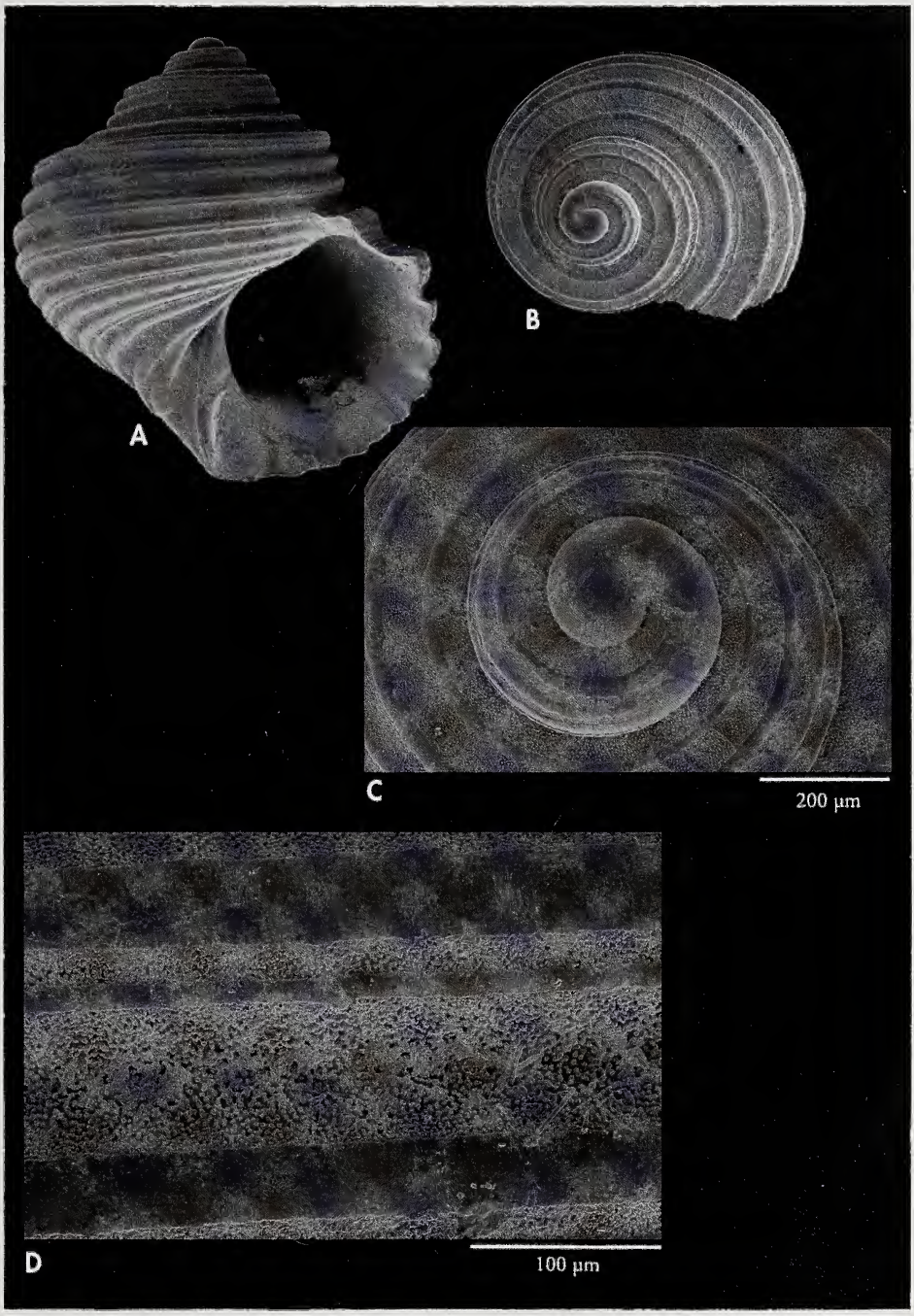

Figure 41. *Haplocochlias bellus* (Dall, 1889). A, B: juveniles, 2.3 and 1.47 mm, Station BIERFK-421, Carysfort Reef, Florida Keys, Monroe Co., Florida, USA (FMNH); C: protoconch, same shell as B; D: microsculpture of the last whorl, same shell as A.

Figura 41. Haplocochlias bellus *(Dall, 1889). A, B: juveniles, 2,3 y 1,47 mm, estación BIERFK-421, Carysfort Reef, Florida Keys, Monroe Co., Florida, USA (FMNH); C: protoconcha, misma concha que B; D: microescultura de la última vuelta, misma concha que A.*

reflection of the columella and the outer lip is thickened slightly and is reflected outward.

Dimensions: Maximum reported size: 3.5 mm

Habitat: USA: Sand Key, 15 fms (27 m) (Dall, 1889); Carisfort Reef, Florida Keys, green mud, 104 m and Key Colony Beach, Florida Keys, muddy sand, 77 m in the present work.

Distribution: USA: North Carolina, East Florida, Florida Keys (Dall, 1889). Cuba: off Havana (Aguayo, 1935; see below). Range: 35°N to 23.15°N; 81.2°W to 76°W].

Remarks: This species has been placed in the genera *Fossarus (Gottoina)*, *Fossarus* and *Parviturbo*. Dall (1889) comments: "*This pretty little shell sometimes has the raised riblets reddish brown against the waxen white of the rest. The nucleus is smaller and less elevated than in* Fossarus ambiguus, *from which, by the way, Gould's* F. pusillus *does not appear to differ specifically*".

In relation to its systematic position Dall (1898) mentions: "*I hesitated for some time as to whether this species should he described where I have placed it, or under* Cyclostrema. *In the absence of the operculum and of the soft parts, it is evident that the question as to its proper classification can only be decided provisionally, and with due reserve*".

The record of Aguayo (1935) for Cuba is considered dubious because it has never been confirmed later. Possibly the species could be confused with *H. ortizi*, which may have a similarity with *H. bellus*.

CONCLUSIONS AND COMMENTS

General information

In the present work, focused on the Recent representatives of the genus *Haplocochlias* (family Skeneidae), we have studied 29 species. From these, 17 were previously known, 11 are described as new to science, and one more is presented as "sp." We have examined more than 600 specimens and shells from all the species from lots loaned by several museums (mainly MCZ, LACM and FMHN), as well as type photographs from other museums (ANSP, USNM) and private collections (see in abbreviations).

With such a numerous group of species and for simplicity of its study we have distributed them into smaller groups based on morphological similarity, assigning the name of each one to the oldest species present (except in one case): *cyclophoreus* group with 5 species; *swifti* group with 7; *ortizi* group with 2; *cubensis* group with 3; *moolenbeeki* group with 10 species, and two additional species which could not be fitted in the groups.

This genus is apparently only present in the Western Atlantic (Caribbean and neighbouring areas) and in the opposite West Central American Pacific coast. The number of species is not equally distributed. Only 6 species were found in the Pacific while there were 23 in the Western Atlantic. As could be expected, the six Pacific species are grouped: three in the *cyclophoreus* group (*H. cyclophoreus*, *H. lucasensis* and *H. multiliratus*); and another three in the *moolenbeeki* group (*H. concepcionensis*, *H. erici* and *H. panamensis*).

This genus can be considered as only superficially studied due to the small size of its shells and the general lack of knowledge of its habitat, which could be interstitial or perhaps among rocks. For these reasons, the collection of living specimens of these species has been usually infrequent. Furthermore, their study requires SEM, not only because of their small size but also due to the necessity of revealing the microsculpture of the protoconch and teleoconch under higher magnification for species-level distinctions; all this makes the study and understanding of the group more challenging. In collections, shells from various localities are probably distinct species but were not distinguished due to lack of literature and diagnostic tools.

Hickman & McLean (1990) consider that both *Haplocochlias* and *Parvi-*

turbo, "are genera from shallow-water with thickened lips". This statement is not entirely correct, because this study has demonstrated that *Haplocochlias* species are distributed from the sublitoral to the continental slope; their bathymetric range from 0 to 200 m.

There are at least 11 species which have been recorded living in bottoms deeper than 50 m (*H. compactus, H. swifti, H. williami, H. ortizi, H. arrondoi, H. nunezi, H. erici, H. francesae, H. panamensis, H. turbinus* and *H. bellus*); conversely only 3 species have been recorded at the intertidal level (*H. moolenbeeki, H. calidimaris* and *H. concepcionensis*). The species collected at greater depth (*H. compactus, H. bellus, H. panamensis* and *H. turbinus*) did not fit completely the generic profile of *Haplocochlias*. Nevertheless, some of their morphological characters are identified with those of this genus, and on this basis we have placed them in *Haplocochlias*.

The species that presents the widest geographical distribution is *H. nunezi*, found from Florida to Nicaragua, on both insular (Cuba, Bahamas and British Virgin Islands) and continental coasts (Florida, Mexico and Nicaragua). In the Bahamas this species occurs in high density as indicated by the large number of individuals collected in sediments. Another species with an apparently wide distribution is *H. swifti* which was found in most of the Caribbean coasts reaching Brazil, although some records may not be valid but a confusion with another species. A limited distribution is more common in most of the studied species: some of them can span two neighbouring countries: *H. pauciliratus* (Bermudas and Bahamas), *H. erici* (Panamá and Colombia), *H. compactus* (Florida, Louisiana, Cuba). But the most common is a smaller distribution which leads us to suppose that there is a high grade of speciation and so of endemism (*H. onaneyi*, Cuba; *H. garciai*, Honduras; *H. minusdentatus*, Bahamas; *H. loperi*, Turks and Caicos; *H. bieleri*, Florida; *H. ortizi*, Cuba; *H. arrondoi*, Cuba; etc.

In some areas (such as Florida and Cuba) we have found together several species: in Florida *H. compactus, H. swifti, H. bieleri, H. calidimaris* and *H. francesae*; in Cuba *H. onaneyi, H. ortizi, H. cubensis, H. nunezi* and *H. pacorubioi*. This is not an unexpected pattern, considering that the evolutionary separation between them may be caused not by broad geographic isolation but by different habitat or different depths within the area where they are living. Also, both Florida and Cuba are among the most studied places in the Caribbean, so that most of the species existing there have been described. A similar situation may be still undetected in other areas which were not so well studied.

With respect to thickening of the outer lip, species here assigned to *Haplocochlias* do not present a common pattern unlike most of the *Parviturbo*, having species with a very thick lip, others with a thin lip, even expanded frontally, and a few with a simple and sometimes even slightly crenulated lip. We have been able to observe how in gerontic specimens, thus morphologically more complete, of species such as *H. nunezi, H. compactus* and *H. bellus*, some characters of the morphology of the shell may be variable. Particularly, the columella becomes thickened and reflected towards the umbilicus, closing it completely and making some of these shells look imperforate. Nevertheless, most of the adult individuals of the same species do not have such a developed columella and therefore, their umbilicus is not completely closed but reduced to a narrow fissure.

The protoconch of the studied shells is always short, with about ¾ of whorl after the nucleus (counted following the method of VERDUIN, 1976). Regarding sculpture, there are only two patterns across all the species: either smooth, or with 4-5 oblique cordlets (two only in one case). This character seems to be somewhat correlated with other morphological characters of the shell, as it appears very irregularly but with predominance of one of the states: in the *cyclophoreus* group there are 4 species with a smooth protoconch and one with cordlets; in the *swifti* group, all have cordlets, but in one species we did not have good material to

Table I. Compared characteristics of the *Haplocochlias* species. H= height; D= maximum diameter; H/D= ratio between height and diameter; SW= spire whorls; PSc= protoconch with sculpture; PS= protoconch smooth; PC= protoconch with cords; CW1= cords on the first whorl; CLW= cords on last whorl; VWL= very wide lip; WL= wide lip; DL= denticulate lip; EF= expanded frontally; CR= crenulated; SC= scalloped; S= simple lip.

Tabla I. Comparativa de características de las especies de Haplocochlias. *H= altura; D= diámetro máximo; H/D= relación entre altura y diámetro; SW= vueltas de espira; PSc= protoconcha con escultura; PS= protoconcha lisa; PC= protoconcha con cordones; CW1= cordones en la primera vuelta; CLW= cordones en la última vuelta; VWL= labio muy ancho; WL= labio ancho; DL= labio denticulado; EF= expandido frontalmente; CR= crenulado; SC= festoneado; S= labio simple.*

	shell				protoconch		shell sculpture		lip
species	H	D	H/D	SW	PSc	PC	CW1	CLW	
H. cyclophoreus	5.15	5.35	0.96	4 ¾	PS	220	4	42	VWL
H. lucasensis	1.7	1.6	1.06	3 ¾	PS	220	4	21	WL
H. compactus	1.63	1.7	0.96	3 ½	PS	220	3-4	22	WL
H. risoneidenerya	4.52	4.3	1.05	5 ¼	PS	200	3-4	24	VWL
H. multiliratus	1.69	1.94	0.82	4	PS	190	3-4	21	VWL
H. swifti	3,70	3,70	1,00	5	PC	220	2	24	DL
H. onaneyi	1,93	1,91	1,01	4	PC	240	2	18	DL
H. garciae	2,18	2,00	1,09	4 1/4	PC	210	2	17	DL
H. williami	1,80	?	?	2 3/4	?	?	2	20	DL
H. minusdentatus	1,25	1,05	1,19	3 1/4	PC	250	4	12	DL
H. loperi	1,29	1,26	1,02	3	PC	260	3	11	DL
H. bieleri	1,56	1,3	1,20	3 1/2	PC	230	2	25	DL
H. ortizi	2,70	3,00	0,90	4 1/2	PC	230	2	20	WL
H. densistriatus	2,15	2,37	0,91	4	PC	220	2	9	WL
H. cubensis	2,51	2,65	0,95	4 1/4	PC	240	3	75	EF
H. arrondoi	2,13	2,17	0,98	3 1/2	PC	240	3 - 4	32	EF
H. harryleei	3,03	3,11	0,97	4 3/4	PC	230	4	28	EF
H. moolenbeeki	4,4	4,7	1,03	5	PS	215	4	34	CR
H. nunezi	4,89	5,42	0,90	5	PC	290	4	53	CR
H. calidimaris	1,75	2	0,88	3 1/4	PC	260	3	10	SC
H. pacorubioi	2,81	2,50	1,12	4 1/2	PS	210	4	46	CR
H. erici	1,95	1,75	1,11	4	PS	170	4	16	CR
H. concepcionensis	5,6	5,60	1,00	5	PS	180	4	17	CR
H. francesae	3,15	3,40	0,96	4 1/2	PS	280	3 - 4	9	SC
H. panamensis	3,78	4,18	0,90	5	PS?	230	4 - 5	29	CR
H. sp	3,9	4,2	0,89	4 3/4	PC?	220	5	35	CR?
H. turbinus	2.75	3.25	0.85	4	PS?	240	3-4	24	CR?
H. pauciliratus	1,47	1,51	0,98	3	PS	250	3 or 4	12	S
H. bellus	3,5	3,5	1,00	4 1/2	PS	270	3 or 4	16-18	SC

examine this point. In *ortizi* and *cubensis* groups, all have cordlets; in the *moolenbeeki* group the predominance is for the smooth protoconchs (7 species); 2 have cordlets and in one this is dubious due to the poor condition of the protoconch; the two ungrouped species are smooth.

In Table I, a comparison of the characters of the different species is made. In order to facilitate the separation of the species in this group we present the following identification key for the genus pointing out the most important characters for each species.

Identification key

1 - Shell robust with a very thick aperture, not or weakly denticulate 2
- Shell with outer lip very thick and internally denticulate 3
- Shell with outer lip not very wide but frontally extended 4
- Shell with a depressed area in the intersection of the outer lip, columela and periumbilical cord 5
- Shell with the columella straight and widened at its base 6
- Shell with simple lip, not thickened, denticulated or crenulated 7

2 - Shell without axial striae and size >5 mm . . . . . *H. cyclophoreus*
- Shell without axial striae, size <2 mm, smooth protoconch . . . . . *H. compactus*
- Shell without axial striae, size <2 mm, protoconch with spiral cordlets . *H. lucasensis*
- Shell with axial striae . . . . . *H. risoneideneryae*
- Shell with axial striae, size 2 mm and smooth protoconch . . . . . *H. multiliratus*

3 - Outer lip with denticulation not very thick . . . . . *H. swifti*
- Outer lip strongly denticulate in its inner margin . . . . . *H. garciai*
- Outer lip with fine denticulation inside (in pairs) border of the lip prominent, umbilical fissure . . . . . *H. onaneyi*
- Outer lip with fine denticulation inside (in pairs) and closed umbilicus . . *H. bieleri*
- Outer lip with fine denticulation and a very sharp angle at its periphery, like a shoulder . . . . . *H. williami*
- Outer lip with light denticulation and first whorl of teleoconch with 4 spiral cords . . . . . *H. minusdentatus*
- Outer lip with light denticulation and first whorl of teleoconch with 3 spiral cords . . . . . *H. loperi*

4 - Shell with rounded periphery and 75 spiral cords in the last whorl . . . *H. cubensis*
- Shell with rounded periphery and 28 spiral cords in the last whorl . . . *H. harryleei*
- Teleoconch with 2 elevated spiral cords as small keels . . . . . *H. arrondoi*

5 - Shell size > 5 mm and smooth protoconch . . . . . *H. moolenbeeki*
- Shell size > 5 mm, smooth protoconch and outer lip reflected . . *H. concepcionensis*
- Shell size > 5 mm and protoconch with spiral cordlets . . . . . *H. nunezi*
- Shell size < 5 mm with outer lip crenulate scallop-shaped . . . . . *H. calidimaris*
- Shell size < 5 mm with spiral cords crossed by delicate axial threads . . . *H. francesae*
- Shell size < 5 mm and smooth protoconch . . . . . *H. pacorubioi*
- Shell size < 5 mm with columellar denticulation . . . . . *H. panamensis*
- Shell size < 5 mm with outer lip reflected . . . . . *H.* sp.
- Shell size < 5 mm with rounded periphery . . . . . *H. turbinus*
- Shell size < 5 mm with 3-4 thin spiral cordlets inside of the umbilicus . . . *H. erici*
- Shell size < 5 mm with spiral striae in the cord interspaces . . . . . *H. bellus*

6 - Last whorl of teleoconch with 20 spiral cords . . . . . *H. ortizi*
- Last whorl of teleoconch with 9 spiral cords . . . . . *H. densistriatus*

7 - Last whorl of teleoconch with 12 spiral cords . . . . . *H. pauciliratus*

APPENDIX 1. Fossil species

There are hitherto only two species in the fossil record of the genus *Haplocochlias*: *Haplocochlias? dominicensis* Aguayo, 1949 from the Middle Miocene of the Dominican Republic, and *Fossarus (Gottoina) mundulus* Guppy, 1896 from the Oligocene of Jamaica.

Other species from the Eocene of Alabama, Oligocene of Florida, Miocene of North Carolina and Miocene and Pliocene of Florida, were described by DALL (1892): *Gibbula americana, Collonia claibornensis, Collonia chipolana, Collonia elegantula* and *Cyclostrema chipolanum*, additional species that could be considered, in our opinion, as belonging to the genus *Haplocochlias* by their general appearance. Two of them, *Collonia chipolana* and *Collonia elegantula* were later transferred by GARDNER (1947) to the genus *Gelasinostoma*, family Turbinidae. This action already was commented on by HICKMAN & MCLEAN (1990: 143) who indicated: "*In the New World,* Gelinasostoma *Gardner, 1947, from the Plio-Pleistocene of the western Atlantic seems to be close to* Haplocochlias".

Below we associate each of the mentioned fossil species, providing the data that we consider of greater interest and their original illustration. As the present work focuses on the Recent species of the genus *Haplocochlias*, we have not revised the type material and therefore we will not make a final assessment with regard to their generic placement.

Haplocochlias? dominicensis Aguayo, 1949

Haplocochlias? dominicensis Aguayo, 1949. *Revista de la Sociedad Malacológica "Carlos de la Torre"*, 6 (3): 92, pl. 4, fig. 8. [Type locality: Gurabo Formation, Middle Miocene, Dominican Republic].

Type material: Holotype in Museo Poey, Universidad de La Habana (nº 11819). Not examined.

Description: Original description in AGUAYO (1949).

Dimensions of the holotype: Height 2.6 mm. Diameter 2.8 mm.

The species is characterized by two prominent spiral cords which are limit and angulate the last whorl of the teleoconch whose profile is practically straight.

Remarks: This is a fossil species from the Middle Miocene Gurabo formation, of the Dominican Republic. After the original description of the species, AGUAYO (1949) wrote: "*La posición genérica es dudosa, pues el único examinado posee las vueltas apicales desgastadas. Por otra parte, la fuerte escultura espiral y la presencia del ombligo, separa esta especie de* Haplocochlias cyclophoreus *Cpr., de las costas de California, a la cual se parece sin embargo, por la forma general y la naturaleza de la abertura. Es también similar a* Haplocochlias swifti *Vanatta, 1913 de Sto. Thomas, Antillas Menores, pero la escultura es muy diferente, así como la naturaleza de la abertura*".

The only species with which it bears a resemblance is *H. pacorubioi*. It differs by having the periphery of the last whorl limited by two cords which form an angle, producing an almost straight profile in apertural view.

Fossarus (Gottoina) mundulus Guppy *in* Guppy & Dall, 1896 (Figure 42A)

Fossarus (Gottoina) mundulus Guppy, 1896. *Proceedings of the United States National Museum*, 19 (1110): 320, pl. 27 fig. 16. [Oligocene of Jamaica, Vendryes].

Type material: Deposited in USNM (nº 107093 and 107094) (*ex* Coll. Guppy nº 2291). Not examined.

Description: See GUPPY & DALL (1896).

Holotype size: Height. 3 mm, diameter 2.75 mm.

Remarks: The great coincidence between the figure of *Fossarus (Gottoina) mundulus* Guppy, 1896 (pl. 27 fig. 16) and that of *Fossarus (Gottoina) bella* Dall, 1889 (*Bulletin of the Museum of Comparative Zoology*, 18, pl. 28 fig. 10) is quite curious, and we might even conclude

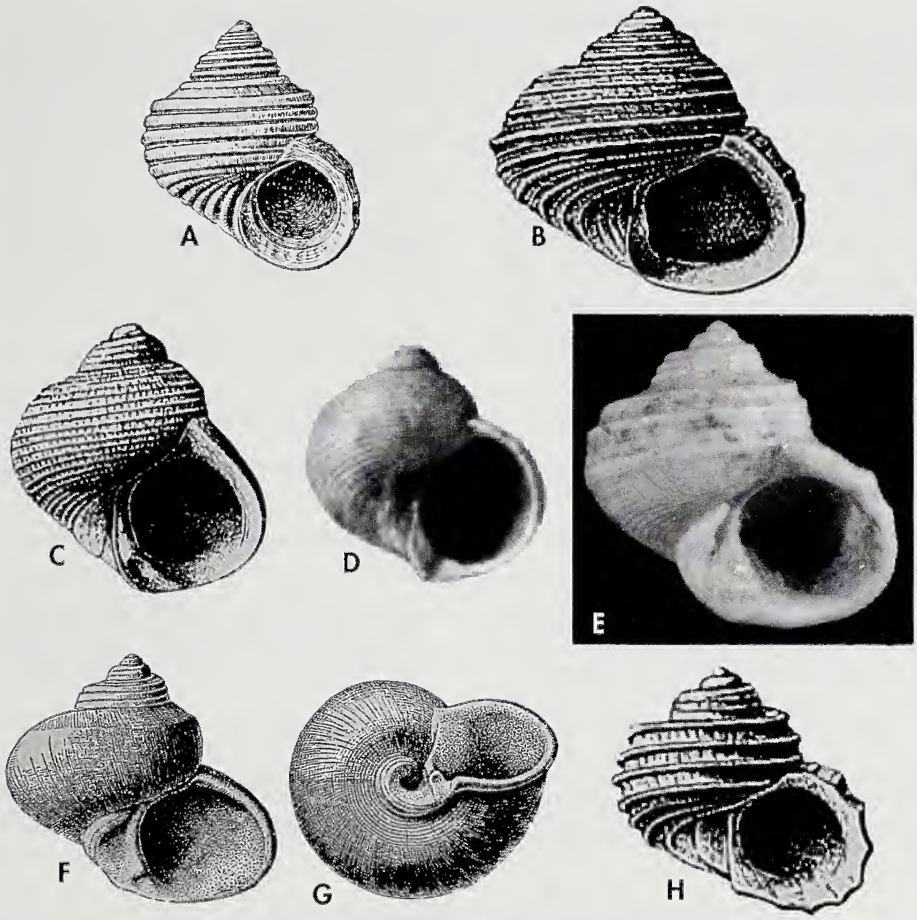

Figure 42. Some fossil species discussed in the text. A: *Fossarus (Gottoina) mundulus* Guppy, 1896 in Guppy & Dall, 1896 (original figure pl. 27 fig. 16); B: *Gibbula americana* Dall, 1892 (original figure pl. 22 fig. 32); C: *Collonia claibornensis* Dall, 1892 (original figure pl. 22 fig. 26); D: *Collonia chipolana* Dall, 1892 (reproduced from Gardner, 1947, pl. 62 fig. 12); E: *Gelasinostoma elegantula*, shell in NMR (62252); F-G: *Collonia elegantula* Dall, 1892 (original figure pl. 19 fig. 3-4); H: *Cyclostrema chipolanum* Dall, 1892 (original figure pl. 22 fig. 35).
Figura 42. Algunas especies fósiles discutidas en el texto. A: Fossarus (Gottoina) mundulus *Guppy, 1896 in Guppy & Dall, 1896 (figura original lám. 27 fig. 16); B:* Gibbula americana *Dall, 1892 (figura original lám. 22 fig. 32); C:* Collonia claibornensis *Dall, 1892 (figura original lám. 22 fig. 26); D:* Collonia chipolana *Dall, 1892 (reproducido de Gardner, 1947, lám. 62 fig. 12); E:* Gelasinostoma elegantula, *concha en NMR (62252); F-G:* Collonia elegantula *Dall, 1892 (figura original lám. 19 fig. 3-4); H:* Cyclostrema chipolanum *Dall, 1892 (figura original lám. 22 fig. 35).*

that it is the same species. Also it is curious that GUPPY & DALL (1896), when they described *F. (G) mundulus*, did not comment on a very similar species described by Dall just a few years earlier. They nevertheless made the following comment: "*This species is not unlike some larger Recent forms found in deep water off the southeastern coast of the United States*", which we think may allude to *Fossarus (Gottoina) bella*, but without an explicit mention.

Gibbula americana Dall, 1892 (Figure 42B)

Gibbula americana Dall, 1892. *Transactions of the Wagner Free Institute of Science of Philadelphia*, 3 (2): 389, pl. 22, fig. 32 [Miocene, Duplin County, North Carolina].

Type material: Holotype (USNM 113010) from near Natural Well, Duplin County, North Carolina (listed in SCHUCHERT *ET AL.*, 1905: 287).

Remarks: In addition to its general shape, the aperture presents many similarities with some Recent *Haplocochlias* species (outer lip expanded outward and columella widened at its base and reflected towards the umbilicus, but without reaching occluding it) as *Haplocochlias ortizi* and *Haplocochlias densicostatus*.

Collonia claibornensis Dall, 1892 (Figure 42C)

Collonia claibornensis Dall, 1892. *Transactions of the Wagner Free Institute of Science of Philadelphia* 3, pt. 2, p. 388, pl. 22, fig. 26 (Eocene, Claiborne, Alabama).

Type material: Holotype (USNM 113002), listed in SCHUCHERT *ET AL.*, 1905: 155.

Remarks: DALL (1892: 386) in relation with the species of the genus *Collonia* Gray, 1850 says: "*The general form of the shells of this genus is more like an elevated* Cyclostrema *than a heavy turbinate* Omphalius, *and the outer lip is expanded and slightly thickened. The sulcus in the lip and the peculiar umbilicus forbid its association with* Cyclostrema, *and the thickened and reflected lip distinguishes it from Solariella; and from* Haplocochlias, *therewise very similar, by its umbilical characters*".

In the original figuration we can observe that the outer lip is expanded, and at the base of the columella there is a depressed area, typical of some species of *Haplocochlias*.

Gelasinostoma chipolanum (Dall, 1892) (Figure 42D)

Collonia chipolana Dall, 1892. *Transactions of the Wagner Free Institute of Science*, 3 (2): 387 (Oligocene, Calhoun County, Florida).
Gelasinostoma chipolanum (Dall, 1892): Gardner, 1947. *United States Geological Survey Professional Paper*, 142-H, p. 612, pl. LXII, fig. 12.

Type material: Holotype (USNM 113001).

Remarks: GARDNER (1947) comments: "*The shell though inmature, is an inmistakable* Collonia, *and I have described it, lest it should be lost sight of, being the only representative of the group in the Chipola Miocene*" *and* "*No other representative of the species or of the genus has been found at any horizon in the Alum Bluff group*".

Gelasinostoma elegantulum (Dall, 1892) (Figure 42E-G)

Collonia elegantula Dall, 1892. *Transactions of the Wagner Free Institute of Science*, 3 (2): 386, pl. 19, figs. 3, 4 (Pliocene, Caloosahatchie River, near Fort Thompson, Florida).
Gelasinostoma elegantulum (Dall, 1892): Gardner, 1947. *United States Geological Survey Professional Paper*, 142-H: 611 (type species of *Gelasinostoma* by original designation).

Type material: "Cotypes" (syntypes) USNM 112996 from Caloosahatchie River, near Fort Thompson, Florida (listed in SCHUCHERT *ET AL.*, 1905: 155).
Material examined: *Gelasinostoma elegantula* (Dall, 1892): Natural History Museum Rotterdam (NMR 66252), Pliocene, Tamiami Formation, Florida.

Remarks: The figured holotype as well as the specimen deposited in the NMR (66252) are very similar *H. onaneyi*, but the latter lacks the depression in the peristome and the strong periumbilical cord present in *G. elegantulum*. GARDNER (1947) considers the depression of the peristome at the extremity of the umbilical keel as a distinctive character not shared by any other group.

Cyclostrema chipolanum Dall, 1892 (Figure 42H)

Cyclostrema chipolanum Dall, 1892. *Transactions of the Wagner Free Institute of Science of Philadelphia*, 3 (2): 420, pl. 22, fig. 35 (Miocene, Bailey's Ferry, Chipola River, Calhoun County, Florida).

Type material: Holotype (USNM 112660), listed in SCHUCHERT *ET AL.*, 1905: 194.

Remarks: The original figuration of this species resembles closely in outline, form and number of spiral cords and shape of the opening and external lip the new species described as *H. pauciliratus* from Bahamas and Bermuda Islands. It differs because this species has a lesser number of spiral cords, a wider periumbilical cord and the external lip reflected outwards apparently scalloped.

APPENDIX 2. Genera not related to *Haplocochlias*

Hereunder we present some comparative information on the genera *Gottoina* and *Lophocochlias* in some occasion considered related.

Genus *Gottoina* A. Adams, 1863

Gottoina A. Adams, 1863. *Proceedings of the Zoological Society of London*. 1863: 110-113. [Type species by subsequent designation (HIGO, CALLOMON & GOTO, 1999): *Conradia (Gottoina) sulcifera* A. Adams, 1863. Gotto, Japan.

Original description: *"Testa turbinoidea seu trochiformis, imperforata; anfractibus transversim liratis. Apertura ovata; labio simplici, arcuato".*

Distribution: Japan and Philippines.

Remarks: *Gottoina* A. Adams, 1863 was described as a subgenus of *Conradia*, family Fossaridae. Until recently both genera were placed in Skeneinae, but HICKMAN (2013) accommodated *Conradia* in a new family Crosseolidae Hickman, 2013 (still in Vetigastropoda).

Gottoina sulcifera A. Adams, 1863 (Figure 43)

Conradia (Gottoina) sulcifera A. Adams, 1863. *Proceedings of Zoological Society of London*, 1863: 110-113. [Type locality: Gotto, Japan].

Type species: One syntype deposited at Museum Victoria, Australia (n° 31453). Not examined.
Other material examined: 1 s, Olango Island, Baring, Philippines, dredged at 180 m (CFR); 2 s, Mactan Island, Punta Engano, Philippines 180-250 m (CFR).

Description: Original description in ADAMS (1863: 113): "*testa depresso-turbinata, albida, solida, rimata, spira obtusa; anfractibus 3 1/2, convexis, liris transversis validis cequalibus, interstitiis longitudinaliter concinne striatis, ornatis; apertura ovata; labio subincrassato, arcuato; labro margine crenulato*. Gotto, 48 fathoms."

The shell is of small size, robust, turbiniform, higher than wide (H/D: 1.25), of dirty whitish/yellowish colour; its spire is composed of 4 ¼ rapidly-expanding whorls. The protoconch is totally smooth, little more than ¾ whorl and measures about 240 μm in diameter. The teleoconch has 3 ½ whorls and is ornamented by strong cords and narrow, deep spiral sulci, with microtubercles and axial striae. Three spiral cords can be seen on the first and second whorls, and 12 on the last; the axial striae cross the spiral cords, more visible on the basal cords; the number of the axial striae increase in number as they approach the last whorl. The shell is imperforate, without even a chink exposed. Aperture rounded, columella arched; no callous coat can be seen in the parietal area. Outer lip sharp, a little modified by the presence of the spiral sulci in the area close to the columella where it is undulant due the width and depth of the sulci.

Dimensions: 3.30 mm in height and 2.62 mm in diameter.

Habitat: Shell dredged at 170 m depth in the Olango Islands, Philippines.

Distribution: Gotto, Japan (A. ADAMS, 1863); Olango and Mactan Islands, Philippines (our material).

Remarks: The shell is imperforate. The modification of the outer lip by the spiral sulci distinguishes this genus from others with imperforate shells.

Genus *Lophocochlias* Pilsbry, 1921

Lophocochlias Pilsbry, 1921. *Proceedings of the Academy of Natural Sciences, Philadelphia*, 72: 377. [Type species by monotypy: *Haplocochlias (Lophocochlias) minutissimus* Pilsbry, 1921, Mokapu Point, Oahu, Hawaii. Recent species].

Distribution: Tropical Indo-West Pacific. Western Pacific, Polynesia.

Remarks: Described originally as a subgenus of *Haplocochlias*. PILSBRY (1921) says: "*By the well-developed varix this shell resembles* Haplocochlias *or* Liotia. *I have placed it in the former genus with doubt. It differs by the very strong sculpture and the open though not wide umbilicus, which may characterize a separate section* Lophocochlias".

KAY (1979) used *Lophocochlias* as a valid genus and retained it tentatively in Skeneidae.

Nevertheless HICKMAN & MCLEAN (1990) do not include *Lophocochlias* in the living genera of Skeneidae.

The systematic position of *Lophocochlias* in Skeneidae is the direct consequence of being initially described as a subgenus of *Haplocochlias* and later considered a valid genus. Yet this does not seem to be the case. In our opinion, the striking morphology of its protoconch does not relate to any known skeneid. Its correct placement will depend on anatomical, radular, and opercular information which is not available now.

Some portals such as GBIF (Global Biodiversity Information Facility) place *Lophocochlias* in Tornidae, but we were not able to find a reason for this systematic placement. Others, such as OBIS Indo-Pacific Mollusca Database, give as the current name *Haplocochlias minutissimus* instead of *Lophocochlias minutissimus*.

Only two species appear related to this genus: *Lophocochlias minutissimus* (Pilsbry, 1921), a Recent species from Oahu, Hawaii and *Lophocochlias paucicarinatus* Ladd 1966, a Cenozoic fossil, from the Miocene of the Marshall Islands.

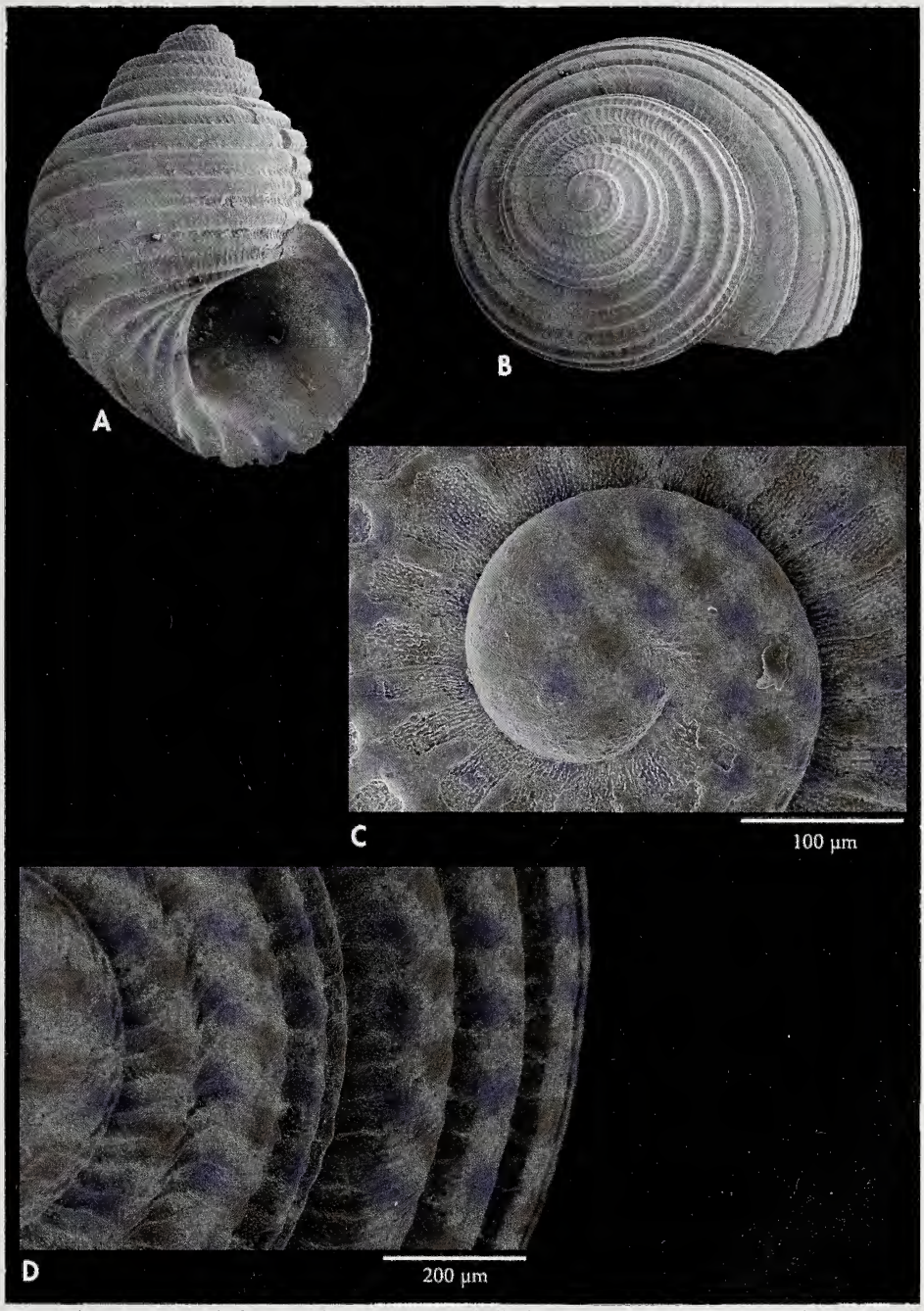

Figure 43. *Gottoina sulcifera* A. Adams, 1863. A: shell, diameter 2.25 mm, Baring, Olango Island, Philippines, dredged at 180 m; B: shell, 2.7 mm, Punta Engaño, Mactan Island, Philippines, 180-250 m. C: protoconch, same shell as B; D: detail of sculpture.

Figura 43. Gottoina sulcifera *A. Adams, 1863. A: concha, diámetro 2,25 mm, Baring, Isla de Olango, Filipinas, dragado en 180 m; B: concha, 2,7 mm, Punta Engaño, Isla de Mactan, Filipinas, 180-250 m. C: protoconcha, misma concha que B; D: detalle de la escultura.*

Lophocochlias minutissimus (Pilsbry, 1921) (Figure 44)

Haplocochlias (Lophocochlias) minutissimus Pilsbry, 1921. *Proceedings of the Academy of Natural Sciences, Philadelphia*, 72: 377. [Type locality: Mokapu Point, Oahu, Hawaii].

Type material: 4 specimens deposited in ANSP (107930). Not examined.
Other material examined: Jordan: 13 s, Aqaba, 10-20 m (MHNS).

Description: Original description in Pilsbry (1921: 377): "*The very small shell is umbilicate, turbinate, not nacreous, white with a conic brownish spire. The first whorl appears to be smooth; on the second fine radial folds or puckering appears below the suture, becoming coarser on the following whorl. The last whorl has six strong, smooth spiral keels, narrower than the intervals, which are flat, and crossed by numerous retractively axial threads, which are much narrower than their intervals. Within the umbilicus two rather small spiral cords are seen. The aperture is quite oblique, subcircular. The outer lip is strengthened by a rounded external rib or varix a short distance behind the edge*".

Length 1 mm, diameter 0.9 mm; 4 1/3 whorls.

Kay (1979) extended the original description: "*Shell turbiniform; spirally keeled and with fine axial threads; white. Protoconch of two and one-half acute, brown whorls, the apical smooth, the others with oblique axial ribs; teleoconch of three convex whorls, the last the largest. Sculpture: apical whorl with granular axial ribs and spiral threads, the next with two and the last with six spiral keels; interspaces between the spiral keels of greater diameter than the keels, shallow, crossed by numerous axial threads. Aperture: subcircular, oblique; outer lip with an external varix; umbilicus wide and deep; operculum circular, multispiral, horny. Color: white*".

Habitat: Subtidal, common in sediments to depths of 30 m and also in tide pools around bases of seaweeds and on solution benches (Kay, 1979). It is an epifaunal species which feeds on detritus.

Distribution: Tropical Indo-West Pacific: Oceania: Polynesia: Hawaiian Islands; French Polynesia: Tuamotu Archipelago; Western Pacific: Marshall Islands (OBIS – Indo Pacific Mollusca Database). From Red Sea in present work.

Remarks: Miocene fossils are reported from the Marshall Islands and Fiji, and a Pleistocene fossil from Tonga (Ladd, 1966). Pilsbry (1921), in an attempt to place this species in a correct genus, created the subgenus *Lophocochlias*, which was considered different from the nominal subgenus *Haplocochlias* due to its stronger sculpture and an open umbilicus. Actually, these morphological characters (lip thickening, wide umbilicus) are present in many turbinoid species; in spite of this, the protoconch appears to be an exclusive character which distinguishes it from Liotiidae and Skeneidae; it is a spectacular protoconch by its development and complex ornamentation. Kay (1979: 56) comments: "*The veliger larvae exhibit both rissoacean and cerithiacean features, resembling rissoids with respect to the inflated shell and cerithids with respect to sculpture and roundedf aperture*".

Ladd (1966) and Sepkoski (2002) list *Lophocochlias* in the family *Skeneidae*, but these are essentially palaeontological compilations and we think that without anatomical, radular, and opercular study it is imposible to place *Lophocochlias* in the proper position with any confidence.

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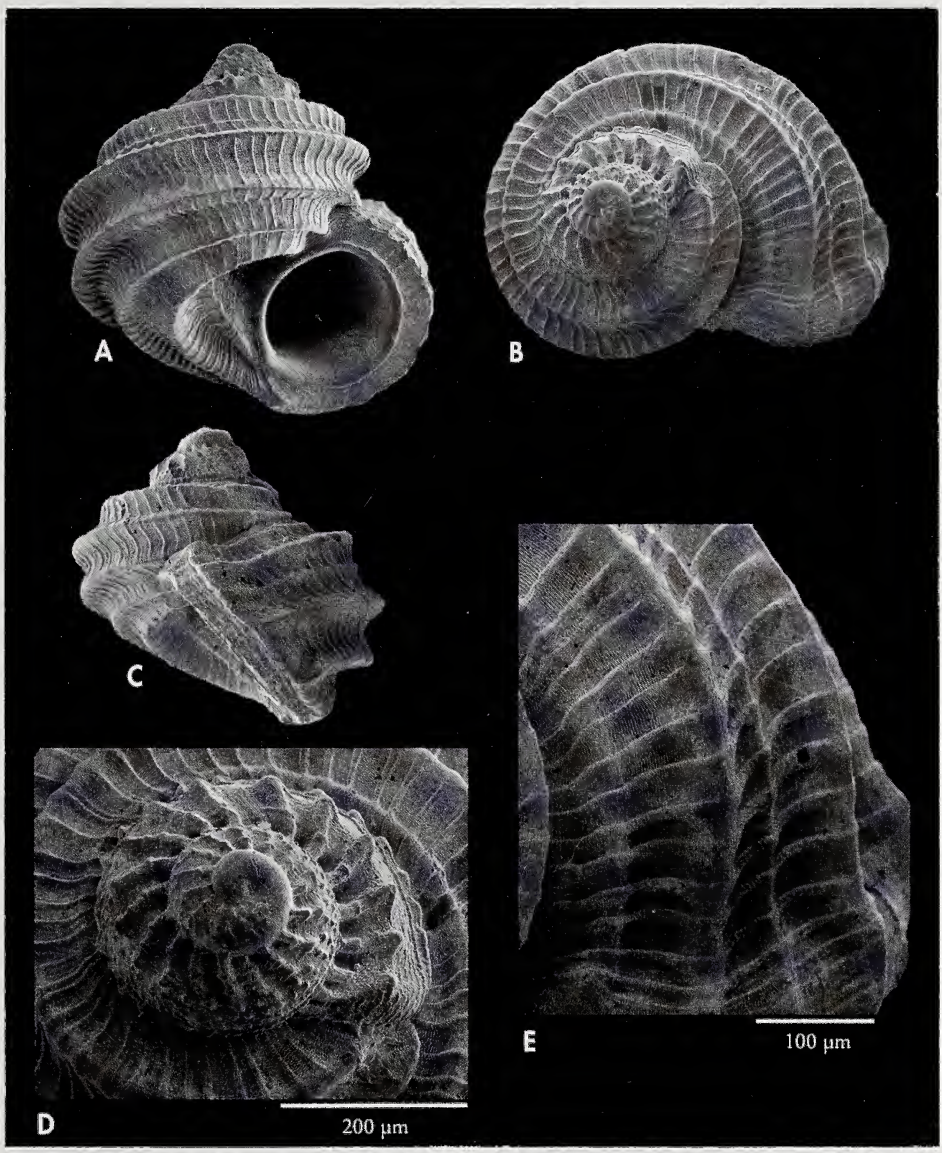

Figure 44. *Lophocochlias minutissima* (Pilsbry, 1921). A-C: shells, 0.91, 0.85, 0.7 mm, Aqaba, Jordan, 25 m (MHNS); D: protoconch; E: sculpture.
Figura 44. Lophocochlias minutissima *(Pilsbry, 1921). A-C: conchas, 0,91, 0,85, 0,7 mm, Aqaba, Jordania, 25 m (MHNS); D: protoconcha; E: escultura.*

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ing the photography of all the necessary material, and ultimately donating several types of the new species unique to his collection.

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Additions to the mollusk checklist of Cocos Island National Park, Costa Rica (Eastern Tropical Pacific)

Adiciones al catalogo de los moluscos del Parque Nacional Isla del Coco, Costa Rica (Pacifico Tropical Este)

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ABSTRACT

During an expedition aimed to study the benthos of subtidal sand bottoms (3-75 m) of Isla del Coco National Park, on the Pacific Ocean side of Costa Rica, a total of 40 species of mollusks were collected and identified. The gastropods were the most diverse with 21 species, followed by the bivalves with 16 species. Also, one species of Polyplacophora, one species of Scaphopoda, and three specimens of Solenogastres (first record of the class in Central American waters) were found in the dredges. Eleven of these species are new additions to the island, and together with literature records, a total of 545 species of mollusks is now known from Isla del Coco. A new species of the genus *Caecum* is described.

RESUMEN

Durante una expedición para el estudio del bentos en el fondo de arena submareal (3-75 m) del Parque Nacional Isla del Coco, Océano Pacífico de Costa Rica, un total de 40 especies de moluscos fue encontrado. Los gasterópodos fueron los más diversos, con 21 especies, seguidos por los bivalvos con 16 especies. También, una especie de Polyplacophora, una especie de Scaphopoda, y 3 ejemplares de Solenogastres (primer registro en aguas de América Central) se encontraron en las dragas. Once de estas especies son nuevas adiciones para la Isla y junto con otras especies citadas en la literatura, suponen un total de 545 especies de moluscos presentes en la Isla del Coco. Se describe una nueva especie del género *Caecum*.

INTRODUCTION

Knowledge of the malacofauna of the Tropical Eastern Pacific Ocean started with material identified during the 19th century, by taxonomists such as d'Orbigny, Broderip, Sowerby I, Lesson, Hinds, Adams, Carpenter, and Dall. During the 20th century, authors like Hertlein and Strong and Olsson published several works. Later, the species of the region were compiled by KEEN (1971) with a taxonomic key, and

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Coan and Valentich-Scott (2012) presented a handbook of the Bivalves with these references and others. In the first decade of the present century, several authors also published taxonomic work on sea slugs (e.g. Camacho-García, Gosliner and Valdés, 2005).

Within the Tropical Eastern Pacific, the oceanic islands of Revillagigedo (Mexico), Clipperton (French possession), Isla Malpelo (Colombia), Galapagos (Ecuador) and Isla del Coco (Costa Rica) are sites of exceptional interest for the study of marine mollusks (Kaiser and Bryce 2001). Due to their geographic position as emerged points of the oceanic sea-floor, these islands are isolated places, with a steep bathymetric gradient, and exposed to changes in intensity and direction of marine currents around the year (Fig. 1).

Studies on the malacofauna of these islands have become more numerous in the last decades. For example, Kaiser and Bryce (2001) studied the mollusks of Isla Malpelo, and mentioned the references of the first expeditions that collected mollusks: Allan Hanckock's Pacific Expedition on *Velero* III in 1931, Smithsonian Tropical Research Institute expedition of 1972, and the *Thornin* expedition in 1990. Kaiser and Bryce (2001) found several new records of micromollusks for this island during their study (1988 to 2000). In the Galapagos, several researchers visited or studied the mollusks with contributions listed in the compilations of Finet (1991) and Finet, Chiriboga, Ruiz, Banks and Tirado (2011). Emerson (1994, 1995) and Kaiser (2007), also studied the mollusks of Revillagigedo and Clipperton. Cortés (2008, 2009), mentioned several studies of marine mollusks in Isla del Coco, for example, those of Biolley (1935), Shasky (1987), Ferreira (1987), Chaney (1992), Kaiser (1998), Hertz and Kaiser (1998). Specimens collected in the majority of studies in Parque Nacional Isla del Coco (PNIC), were obtained from occasional surveys, during dives, mostly on rocky and coral reefs. Montoya (1988) did some dredging and netting at random sites around the island during the *Victoria af Carlstat* expeditions between 1983-1989, with the collaboration of Shasky and Kaiser and increased the fauna from surveys in different habitats, producing more than 50 taxonomic publications (Cortés, 2008; 2009). Recently we have had access to an unpublished manuscript based on these expeditions to the island, by Montoya, Shasky and Kaiser (unpublished manuscript, 1988), with title: "The marine Mollusca of Isla del Coco, Costa Rica".

The present study used a quantitative sampling, employing a van Veen grab and 500 μm mesh sieves to retain macro and micromollusks. The main goals of the project were to collect specimens and identify them to the lowest taxonomic level possible in order to increase the number of species reported from Isla del Coco National Park, to describe new species if appropriate, and to understand the biogeographic affinity of the species found, compared to other sites of the Tropical Pacific Ocean.

MATERIAL AND METHODS

The Isla del Coco National Park was visited during the UCR-UNA-COCO-I expedition on board the *M/V Argo* from 19 to 29 April 2010. Isla del Coco is about 500 km from the mainland of Costa Rica, and more than 630 km from Isla Malpelo and the Galapagos Islands (Lizano, 2001) (Fig. 1, Fig. 2). At each of 27 sampling stations, between 3 and 75 m depth (Fig. 2 and Table I), five sediment samples were collected with a van Veen grab (total sampling area per station: 0.31 m^2) (Sibaja-Cordero, Troncoso and Cortés, 2012). Organisms were stained with rose bengal and preserved with formalin diluted to 5% in sea water. The samples were later sieved through a 500 μm mesh and the sorted material stored in glass vials filled with 70% ethanol (Vargas, 1987; Sibaja-Cordero *et al.*, 2012).

The species were identified using mainly the keys of Keen (1971) and Coan and Valentich-Scott (2012), as well as original descriptions, and illustrations on

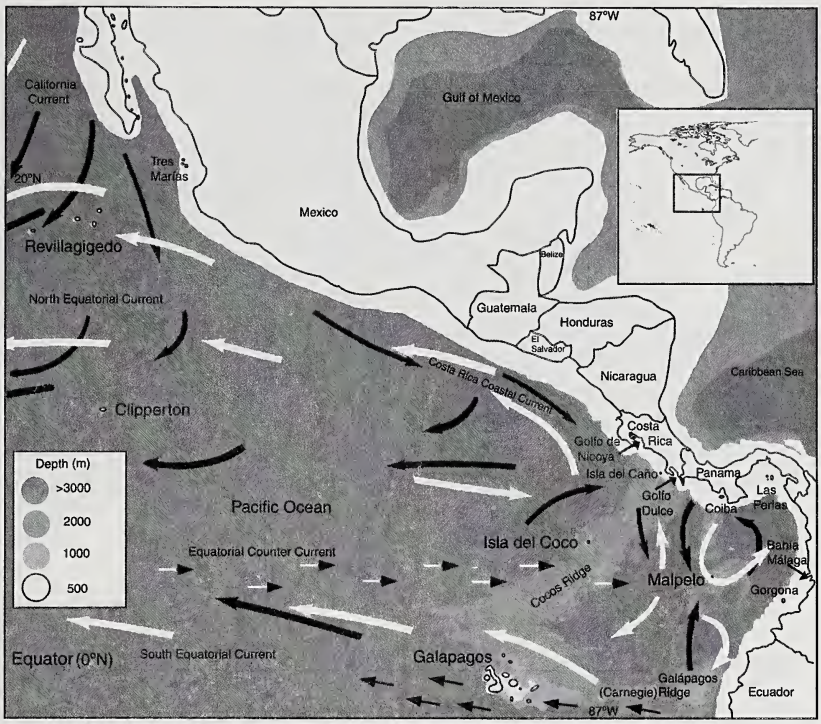


Figure 1. Eastern Tropical Pacific Ocean, showing the location of the main oceanic currents and islands. Black arrows indicate the direction of the currents in April, the white arrows in October, and black-white arrows indicate the direction of the Equatorial Countercurrent in October (Based on HENDRICKX, 1995; LIZANO, 2008).

Figura 1. Oceano Pacifico Tropical Este, se muestra la ubicación de las principales Corrientes oceanicas e islas. Flechas negras indican la dirección de las corrientes en abril, las fleches blancas en octubre, y las fleches blanco-negro indican la dirección de la Contracorriente Ecuatorial en octubre (Basado en HENDRICKX, 1995; LIZANO, 2008).

the web page of the Natural History Museum Rotterdam (www.nmr-pics.nl). The specimens were deposited in the Museo de Zoología (MZUCR), Escuela de Biología, Universidad de Costa Rica (UCR), Costa Rica. The sampling was part of a comprehensive study of the benthic community of the island (SIBAJA-CORDERO, 2012), therefore a code number was assigned to each species, and maintained for the species presented here (Codes 45 to 84). The code is part of the information in the museum label. The station (st.) and dredge (d.) in which each species was found, is also given.

Scanning Electron Microscopy (SEM) was necessary to identify the specimens of a gastropod of the genus *Caecum*. These shells have been cleaned with distilled water, and remains of adhered tissue were removed with a fine forceps and an ultrasonic bath (20 sec). The shells were dried under an incandescent lamp (4 hr). Subsequently, using a double-sided tape, the specimens were placed on an aluminum stub for SEM; silver paint was added to the edges of this tape to increase the conductivity. The samples were covered with Pd/Pt alloy using an "ion coater" (Model Giko IB-3), for 4 min. The specimens were then examined in a SEM (Hitachi model S-570) and photomicrographs were taken of the complete shell (frontal and lateral view), the detail of the sculpture, and details of the septum, the aperture and the operculum.

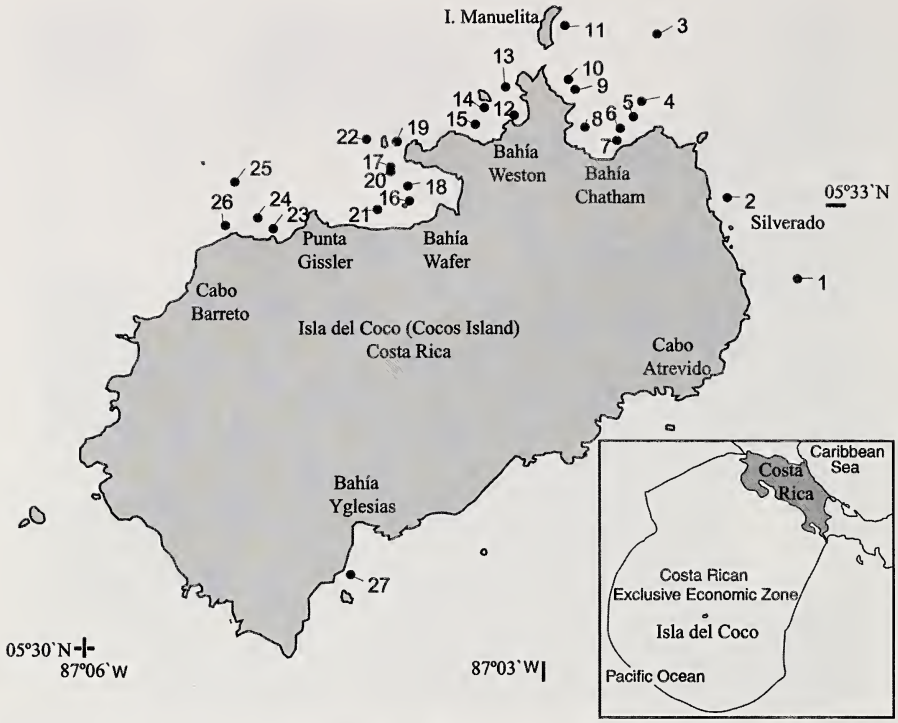


Figure 2. Sampling stations (1-27) around Isla del Coco, Costa Rica. April 2010.
Figura 2. Estaciones de muestreo (1-27) alrededor de la Isla del Coco, Costa Rica. Abril 2010.

RESULTS

A total of 434 specimens of mollusks, distributed in 40 species, were found in the sediment of Isla del Coco, between 3 and 75 m depth. The gastropods were the most diverse with 21 species, followed by the bivalves with 16 species. Also, one species of Polyplacophora, Scaphopoda, and Solenogastres were found in the dredges. The following paragraphs privide comments for each species, on their characteristics, habitat, and distribution.

Phylum MOLLUSCA
Class BIVALVIA Linnaeus, 1758
Subclass PTERIOMORPHIA Beurlen, 1944
Order PTERIOIDA Newell, 1965
Family PTERIIDAE Gray, 1847 (1820)
Genus *Isognomon* Lightfoot, 1786

Isognomon (*Melina*) *janus* P. P. Carpenter, 1857 (Figure 3; Code 45)

Isognomon janus P.P. *Carpenter*, 1857: 151-152; Brann, 1966: pl. 17, fig. 206-689.
Isognomon (*Melina*) *janus* P.P. Carpenter, 1857 – Coan and Valentich-Scott, 2012: 220, pl. 72.

Material studied: Bahía Wafer: st. 19, d. 4, 20 m. 3 ind.

Table I. Latitude, longitude and depth at low tide level (0 m) of the sampling stations. Isla del Coco, Costa Rica.
Tabla I. Latitud, longuitud y profundidad al nivel de marea baja (0 m) de las estaciones de muestreo. Isla del Coco, Costa Rica.

Locality	Station	Latitude (N)	Longitude (W)	Depth (m)
El Arco	1	5°32'11.0"	87°01'22.5"	60.1
Silverado	2	5°32'40.2"	87°01'47.7"	9.7
Bahía Chatham	3	5°33'39.4"	87°02'13"	74.8
Bahía Chatham	4	5°33'15.0"	87°02'18.6"	34.8
Bahía Chatham	5	5°33'09.3"	87°02'21.6"	16.0
Bahía Chatham	6	5°33'5.20"	87°02'26.4"	8.4
Bahía Chatham	7	5°33'00.8"	87°02'27.6"	4.6
Bahía Chatham	8	5°33'05.6"	87°02'39.1"	2.6
Bahía Chatham	9	5°33'19.2"	87°02'42.6"	10.0
Bahía Chatham	10	5°33'22.9"	87°02'45"	10.6
Bahía Chatham	11	5°33'42.6"	87°02'46.2"	15.0
Bahía Weston	12	5°33'09.9"	87°03'4.6"	9.9
Bahía Weston	13	5°33'20.2"	87°03'7.7"	42.1
Bahía Weston	14	5°33'12.7"	87°03'15.4"	18.5
Bahía Weston	15	5°33'06.7"	87°03'18.6"	12.2
Bahía Wafer	16	5°32'39.1"	87°03'42.6"	3.5
Bahía Wafer	17	5°32'51.5"	87°03'49.2"	23.0
Bahía Wafer	18	5°32'44.4"	87°03'43"	7.8
Bahía Wafer	19	5°33'00.4"	87°03'46.9"	24.2
Bahía Wafer	20	5°32'49.7"	87°03'49.2"	39.8
Bahía Wafer	21	5°32'36.1"	87°03'54"	7.2
Bahía Wafer	22	5°33'01.3"	87°03'58"	70.9
Punta Gissler	23	5°32'29.0"	87°04'31.7"	11.2
Punta Gissler	24	5°32'32.9"	87°04'37.1"	15.8
Punta Gissler	25	5°32'45.9"	87°04'45.5"	53.2
Punta Gissler	26	5°32'30.2"	87°04'48.9"	12.6
Bahía Yglesias	27	5°30'24.4"	87°04'3.8"	12.5

Size: 2.6 × 2.0 mm.

Remarks: The specimens found are juveniles, similar to figure 163 in Keen (1971), and resembles the outline of the holotype (adult) in plate 72 of COAN AND VALENTICH-SCOTT (2012). The valves are tongue-shaped and have few pits along the hinge margin. The commarginal lamellae are thin in the margins (CARPENTER, 1857; KEEN, 1971; COAN AND VALENTICH-SCOTT, 2012).

Distribution: This species is widely distributed in the Tropical Eastern Pacific (KEEN, 1971; MAGAÑA-CUBILLO AND ESPINOSA, 2009) and was previously reported along the Pacific of Costa Rica (INBIO, 1989; MAGAÑA-CUBILLO AND ESPINOSA, 2009). It also occurs in oceanic islands of the Tropical eastern Pacific: Revillagegido, Clipperton, Isla del Coco, Malpelo, and Galapagos (MAGAÑA-CUBILLO AND ESPINOSA, 2009; FINET *ET AL.*, 2011; COAN AND VALENTICH-SCOTT, 2012). The specimens were attached to a small fragment of rhodolith within the sand bottom. MAGAÑA-CUBILLO AND ESPINOSA (2009) report the species as subtidal in rubble or sand, and SOLANO (2011) had already found this species in a rhodolith bed at 20 m depth in Punta Ulloa, PNIC.

Order Arcoida Stoliczka, 1871
Family Glycymerididae Dall, 1908 (1847)
Genus *Tucetona* Iredale, 1931

Tucetona strigilata (G.B. Sowerby I, 1833) (Figure 4 a-c, Code 46)

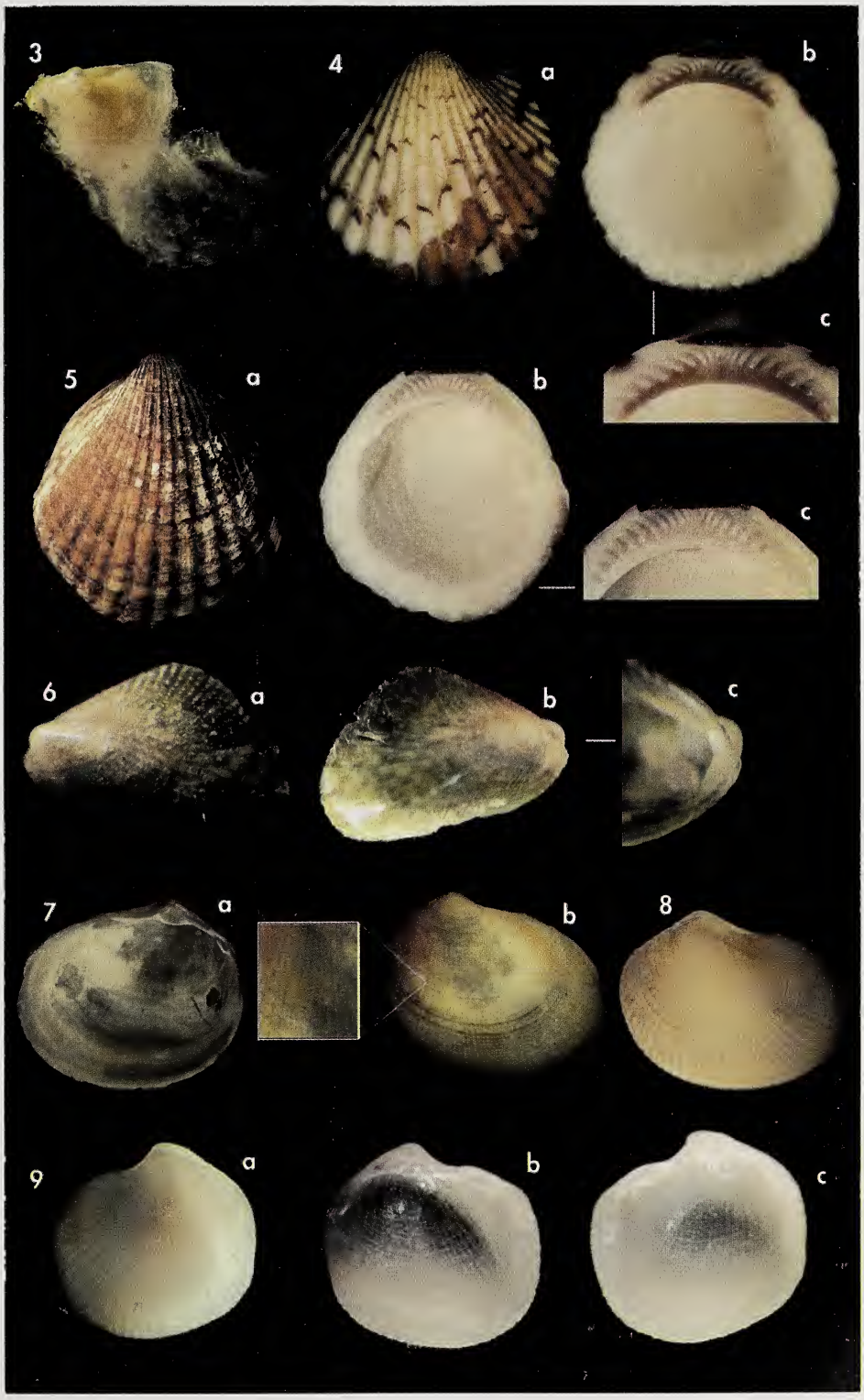
Pectunculus strigilatus G.B. Sowerby I, 1833, *Proc. Comm. Sc. Corresp. Zool. Soc. London*, 2: 196.
Pectunculus tesselatus G.B. Sowerby I, 1833, *Proc. Comm. Sc. Corresp. Zool. Soc. London*, 2: 196.
Glycymeris (*Tucetona*) *strigilata* (Sowerby, 1833) – Keen, 1971: 57.
Tucetona strigilata (G.B. Sowerby I, 1833) – Huber, 2010: 156, 584; Coan and Valentich-Scott, 2012: 199, pl. 65.

Material studied: El Arco: st. 1, d. 2, 61 m. 4 juvenile ind.
Size: 8.0 × 8.0 – 22.1 × 22.2 mm.

Remarks: The valves are comparable to Fig. 117 of Keen (1971) and to the picture of a specimen from Sinaloa, Mexico (catalogue number NMR 19662) in Natural History Museum Rotterdam (NMR). Moreover, there is some degree of variation in the outline as compared with fig 65 of Coan and Valentich-Scott (2012). *Tucetona multicostata* G.B. Sowerby I, 1833 is similar, but the specimen in PNIC, has 25 wider ribs (Fig. 4a), within the range reported for *T. strigilata*, while *T. multicostata* would have have 31-43 radial ribs (Coan and Valentich-Scott, 2012). These ribs in specimens of PNIC are not bifurcate, and the valves have spots of brown or reddish color. The hinge is linear near the umbo like Fig. 10 of Valentich-Scott and Garfinkle (2011). The margins are not heavily crenulated in contrast with *T. multicostata*. The specimens in Isla del Coco presented a brown or white wide region below the teeth (Fig. 4b). The number of 12-15 anterior and 13-18 posterior teeth were reported for *T. strigilata* (Coan and Valentich-Scott, 2012), but in specimens of PNIC, they range between 6-10 anterior and 6-11 posterior (Fig. 4c), the tooth number increasing with shell size.

Distribution: From Baja California to Ecuador (Keen, 1971). Present along the Pacific Coast of Costa Rica, and Isla del Coco (INBio, 1989; Magaña-Cubillo and Espinosa, 2009). The species also occurs on the continental island of Gorgona (UAESPNN, 2005, Appendix III).

(Right page) Figure 3. *Isognomon janus* Carpenter, 1857, 2.6 × 2.0 mm, st. 19. Figure 4. *Tucetona strigilata* (G. B. Sowerby I, 1833), a: valve, exterior view; b: interior view; c: detail of the hinge, 22.1 × 22.2 mm, st. 1. Figure 5. *Tucetona* sp., a: valve, exterior view; b: interior view; c: detail of the hinge, 22.6 × 20.5 mm, st. 3. Figure 6. *Septifer zeteki* Hertlein and Strong, 1946, a: valve, exterior view; b: interior view and detail of the hinge, 1.4 × 1.5 mm, st. 11. Figure 7. *Ctena clarionensis* Hertlein and Strong, 1946, a: interior view; b: exterior view and detail of the sculpture, 5.2 × 5.3 mm, st. 19. Figure 8. *Ctena mexicana* (Dall, 1901), 2.3 × 3.0 mm, st. 26. Figure 9. *Parvilucina mazatlanica* (Carpenter, 1857), a: exterior view; b: interior view of the valves, 3.5 × 3.6 mm, st. 18.
(Página derecha) Figura 3. Isognomon janus *Carpenter, 1857, 2,6 × 2,0 mm, est. 19. Figure 4.*Tucetona strigilata *(G. B. Sowerby I, 1833), a: valva, vista exterior; b: vista interior; c: detalle de la charnela, 22,1 × 22,2 mm, est. 1. Figura 5.* Tucetona *sp., a: valva, vista exterior; b: vista interior; c: detalle de la charnela, 22,6 × 20,5 mm, est. 3. Figura 6.* Septifer zeteki *Hertlein y Strong, 1946, a: valva, vista exterior; b: vista interior y detalle de la charnela, 1,4 × 1,5 mm, est. 11. Figura 7.* Ctena clarionensis *Hertlein y Strong, 1946, a: vista interior; b: vista exterior y detalle de la escultura, 5,2 × 5,3 mm, est. 19. Figura 8.* Ctena mexicana *(Dall, 1901), 2,3 × 3,0 mm, est. 26. Figura 9.* Parvilucina mazatlanica *(Carpenter, 1857), a: vista exterior; b: vista interior de las valvas), 3,5 × 3,6 mm, est. 18.*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Tucetona sp. (Figure 5 a-c, Code 47)

Material studied: Bahía Chatham: st. 3, d. 1, 74m. 1 ind.

Size: 22.6 × 20.5 mm.

Remarks: This bivalve resembles *T. strigilata* in the outline, number of radial ribs (25), number of teeth (11 anterior, and 11 posterior). On the other hand, the specimen has a reddish-brown periostracum and narrow radial ribs, marked commarginal ribs spaced along the shell and several commarginal striae marked ventrally. The specimen is similar in sculpture to *Tucetona canoa* (Pilsbry and Olsson, 1941), which Coan and Valentich-Scott (2012) synonimized with *T. strigilata*, but differs in the marked commarginal ribs and exterior brown color without chevrons, bands or blotches. More sampling is required to determine the identity of this specimen.

Distribution: Other species are present in the Tropical Eastern Pacific (Coan and Valentich-Scott, 2012), but differ in several characteristics from this individual.

Order Mytiloida Ferussac, 1822
Family Mytilidae Rafinesque, 1815
Genus *Septifer* Dunker, 1855

Septifer zeteki Hertlein and Strong, 1946 (Figure 6 a-c, Code 48)

Septifer zeteki Hertlein and Strong, 1946, *Zoologica: Sci. Contr. New York Zool. Soc.*, 31: 71, pl. 1 figs. 1-2.; Coan and Valentich-Scott, 2012: 151, pl. 49.

Material studied: Manuelita: st. 11, d. 1, 13.6m. 1 ind.

Size: 1.4 × 1.5 mm.

Remarks: Species of *Septifer* are similar to *Brachidontes* but with a shelly septum on the tip of valve (Fig. 6c). The small valves of the specimen found are identified to *Septifer zeteki* Hertlein and Strong, 1946 as shown in figure 129 of Keen (1971); they are greenish in color and with bifurcate ribs as in plate 49 of Coan and Valentich-Scott (2012).

Distribution: This is the only species of *Septifer* reported from Baja California to Peru. Present in Revillagigedo (Coan and Valentich-Scott, 2012), Isla del Coco (INBio, 1989; Magaña-Cubillo and Espinosa, 2009), Galapagos (Finet *et al.*, 2011), Malpelo and Gorgona (UAESPNN, 2005, Appendix III; Coan and Valentich-Scott, 2012). The specimen of PNIC was found attached by the byssus to a pebble in the sand bottom.

Subclass Heterodonta Neumayr, 1884
Order Lucinoida Gray, 1854
Family Lucinidae Fleming, 1828
Genus *Ctena* Mörch, 1861

Ctena clarionensis Hertlein and Strong, 1946 (Figure 7 a-b, Code 49)

Ctena clarionensis Hertlein and Strong, 1946, *Zoologica: Sci. Contr. New York Zool. Soc.*, 31: 118; Coan and Valentich-Scott, 2012: 340, pl. 109.

Material studied: Bahía Wafer: st. 19, d. 1, 27.8m. 1 ind.

Size: 5.2 × 5.3 mm.

Remarks: The specimen is similar to figure 281 of KEEN (1971) and plate 109 of COAN AND VALENTICH-SCOTT (2012). This individual has 75 radial ribs with dense commarginal ribs in crossbars intersections (Fig. 7b). *Ctena clarionensis* is similar in outline to *Ctena mexicana* (Dall, 1901), but has valves with very fine and numerous radial ribs (about 80), while *C. mexicana* only has 30 to 50 radial ribs. The specimens of PNIC also presented the somewhat bifid posterior cardinal in the right valve (Fig. 7a).

Distribution: Baja California to Ecuador (KEEN, 1971). The species is present along the Pacific coast of Costa Rica mainland (INBIO, 1989). Reported from Revillagigedo, Clipperton, and Isla del Coco (KEEN, 1971; MAGAÑA-CUBILLO AND ESPINOSA, 2009; COAN AND VALENTICH-SCOTT, 2012).

Ctena mexicana (Dall 1901) (Figure 8, Code 50)

Lucina pectinata P.P. Carpenter, 1857: 98-99 (preoccupied name).
Codakia (Jagonia) mexicana Dall, 1901, *Proc. U.S. Nat. Mus.*, 23: 801, 822, pl. 40 fig. 6 (replacement name).
Ctena mexicana (Dall 1901) – Keen 1971: 125; Coan and Valentich-Scott, 2012: 341, pl. 110.

Material studied: Punta Gissler: st. 26, d. 2, 12.1m, 1 ind.

Size: 2.3 × 3.0 mm.

Remarks: In this small juvenile specimen, the shell is subovate, with the anterior end longer, and with 47 strong radial ribs extending to valve margin. The internal ventral margin looks denticulate. Commarginal striae are comparable to plate 110 of COAN AND VALENTICH-SCOTT (2012), and Fig. 284 of KEEN (1971). The internal characteristics of both valves agree with the description of COAN AND VALENTICH-SCOTT (2012).

Distribution: Baja California to Colombia (COAN AND VALENTICH-SCOTT, 2012), Pacific coast of Costa Rica (INBIO, 1989; MAGAÑA-CUBILLO AND ESPINOSA, 2009, REVILLAGIGEDO, MALPELO (COAN AND VALENTICH-SCOTT, 2012), and Galapagos (FINET *ET AL.*, 2011). The species is a new record for Isla del Coco.

Genus *Parvilucina* Dall, 1901

Parvilucina mazatlanica (Carpenter, 1857) (Figure 9 a-c, Code 51)

Lucina mazatlanica Carpenter, 1857: 99-100; Brann, 1966, pl. 12, Fig. 144-472.
Lucina (Parvilucina) mazatlanica (Carpenter, 1857); Keen, 1971: 121.
Parvilucina mazatlanica (Carpenter, 1857); Odé, 1977, *Texas conchol.*, 14: 17; Coan and Valentich-Scott, 2012: 354, pl. 115 (redescription).

Material studied: Bahía Chatham: st. 4, d. 1, 33.8 m, 3 ind; st. 9, d. 3, 10 m, 1 ind; st. 9, d. 4, 10m, 1ind; st. 9, d. 5, 9.9 m, 2 ind; st. 10, d. 3, 10.6 m, 1 ind; st. 10, d. 5, 10.7 m, 3 ind. – Bahía Wafer: st. 17, d. 4, 27.6m, 1 ind; st. 18, d. 5, 7.3 m, 1 ind; st. 20, d. 3, 38.1 m, 1 ind; st. 20, d. 4, 38.2 m, 1 ind.

Size: 1.1 × 1.2 - 3.5 × 3.6 mm.

Remarks: These are small specimens similar to Fig. 275 of KEEN (1971), with the reticular sculpture (Fig. 9a), radial ribs weak at the middle, the disposition of the lateral teeth, and the shape of the lunule (Fig. 9b-c). Also, matches with the subquadrate shell outline in pl. 12, Fig. 144-472 of Brann, 1966, and plate 115 of COAN AND VALENTICH-SCOTT (2012).

Distribution: Gulf of California to Panama (KEEN, 1971). The species was known for the Pacific coast of mainland Costa Rica (INBIO, 1989; MAGAÑA-

Cubillo and Espinosa, 2009) but not reported from any other oceanic island of the Tropical Eastern Pacific; it is a new record for Isla del Coco.

Order Veneroida Gray, 1854
Family Montacutidae W. Clark, 1855
Genus *Planktomya* Simroth, 1896

Planktomya cf. *henseni* Simroth, 1896 (Figure 10 a-d, Code 52)

?*Planktomya henseni* Simroth, 1896: *Ergebn. Plankton-Exped. Humboldt-Stiftung, 2 (6)*: 28, pl. 1, Fig. 1A-C.; Coan and Valentich-Scott, 2012: 458, pl. 152.

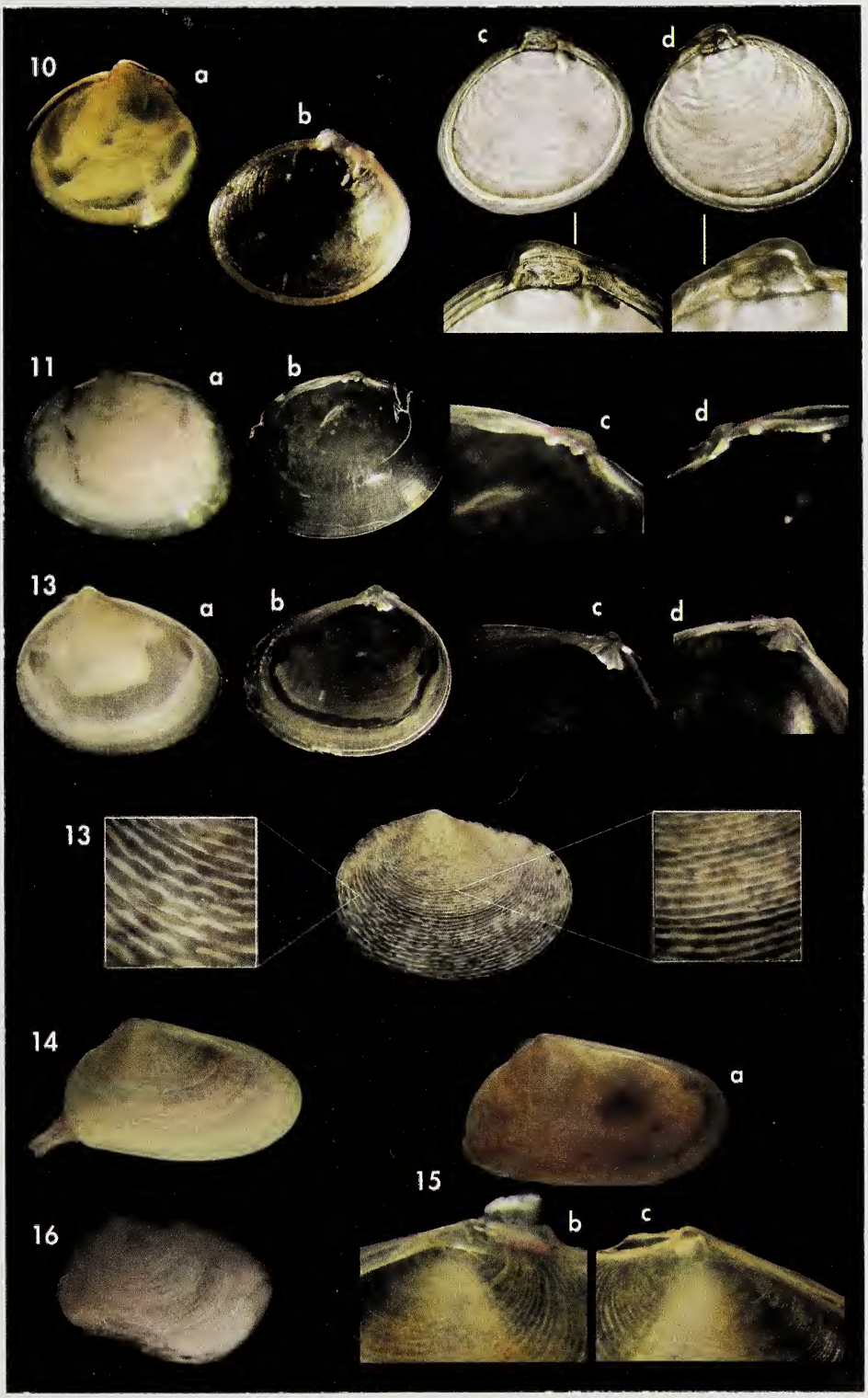
Material studied: Silverado: st. 2, d. 1, 9.5 m, 1 ind; st. 2, d. 2, 9.5 m, 3 ind; st. 2, d. 4, 10.6 m, 1 ind. – Bahía Chatham: st. 4, d. 5, 34.9 m, 1 ind; st. 6, d. 5, 8.4 m, 1 ind. – Bahía Weston: st. 13, d. 5, 42.3 m, 2 ind; st. 14, d. 4, 18.6 m, 1 ind; st. 14, d. 5, 18.6 m, 1 ind. – Punta Gissler: st. 26, d. 2, 12.1 m, 1 ind. – Bahía Yglesias: st. 27, d. 4, 13.6 m, 2 ind.

Size: 0.3 × 0.4 mm.

Remarks: Specimens have soft and orange shells, and possibly these had been recently fallen on the sea-bottom, however, several features are clearly seen in the specimens. The valves are very small, fragile, transparent, oblique, inequilateral, with anterior end longer, and with opisthogyrate umbos (Fig. 10a). They have no radial sculpture, but have weak commarginal lines that may be seen from the inside of the shell (Fig. 10b). The elements of ligament appear internally and the hinge has well developed cardinal teeth. In the right valve, the cardinal teeth are separate (Fig. 10c) while in the left valve are close together (Fig. 10d). The lateral teeth are small. These valves agree with most of the characters of *Planktomya henseni* Simroth, 1896 and resemble plate 152 of this species in Coan and Valentich-Scott (2012). These authors point out the extensive planktonic life stage of this bivalve, and that in the adult stage it settles on the benthos.

Distribution: The type locality of this species is in the Carribean Sea, but in the Tropical Eastern Pacific, this species occurs from Nayarit, Mexico to the Galapagos, including in its distribution a record from Isla Manuelita, Isla del Coco (Coan and Valentich-Scott, 2012).

(Right page) Figure 10. *Planktomya* cf. *henseni* Simroth, 1896, a: exterior view; b: interior view; c: right valve; d: left valve, 0.3 × 0.4 mm, st. 14. Figure 11. *Diarmaidia jingchunae* Valentich-Scott, in Coan and Valentich-Scott, 2012, a: external view; b: internal view; c: teeth of the left valve; d: teeth of the right valve, 2.0 × 1.7 mm, st. 14. Figure 12. *Diplodonta* sp., a: exterior view; b: interior view; c: teeth of the right valve; d: teeth of the left valve, 1.3 × 1.7 mm, st. 14. Figure 13. *Semele* (*Amphidesma*) *formosa* (G. B. Sowerby I, 1833), 3.2 × 15.1 mm, st. 19. Figure 14. *Tellina* (*Moerella*) sp., 1.0 × 2.0 mm, st. 4. Figure 15. *Tellina* (*Moerella*) *coani* (Keen, 1971), a: external view; b: teeth of the right valve; c: teeth of the left valve, 2.6 × 4.5 mm, st. 25. Figure 16. *Tellina* (*Laciolina*) sp., 1.0 × 2.2 mm, st. 15. Isla del Coco. April 2010.
(Página derecha) Figura 10. Planktomya *cf.* henseni *Simroth, 1896, a: vista exterior; b: vista interior; c: valva derecha; d: valva izquierda, 0,3 × 0,4 mm, est. 14. Figura 11.* Diarmaidia jingchunae *Valentich-Scott, en Coan y Valentich-Scott, 2012, a: vista externa; b: vista interna; c: dientes de la valva izquierda; d: dientes de la valva derecha, 2,0 × 1,7 mm, est. 14. Figura 12.* Diplodonta *sp., a: vista exterior; b: vista interior; c: dientes de la valva derecha; d: dientes de la valva izquierda, 1,3 × 1,7 mm, est. 14. Figura 13.* Semele (Amphidesma) formosa *(G. B. Sowerby I, 1833), 3,2 × 15,1 mm, est. 19. Figura 14.* Tellina (Moerella) *sp., 1,0 × 2,0 mm, est. 4. Figura 15.* Tellina (Moerella) coani *(Keen, 1971), a: vista externa; b: dientes de la valva derecha; c: dientes de la valva izquierda, 2,6 × 4,5 mm, est. 25. Figura 16.* Tellina (Laciolina) *sp., 1,0 × 2,2 mm, est. 15. Isla del Coco. Abril 2010.*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Family LASAEIDAE J. E. Gray, 1842
Genus *Diarmaidia* Valentich-Scott, in Coan and Valentich-Scott, 2012

Diarmaidia jingchunae Valentich-Scott, in Coan and Valentich-Scott, 2012 (Figure 11 a-d, Code 53)

Diarmaidia jingchunae Valentich-Scott, in Coan and Valentich-Scott, 2012: 506, pl. 167.

Material studied: Bahía Weston: st. 14, d. 1, 18.5 m, 1 ind.

Size: 2.0 × 1.7 mm.

Remarks: The valves are almost ovate, much longer posteriorly (Fig. 11a), with cardinal teeth in a central position. They have few low radial ribs on the edges, visible from inside, and also a commarginal sculpture that can be seen from inside the shell (Fig. 11b). The ligament is mostly internal. The hinge has two small cardinal teeth. In the right valve, a small cardinal joins to a posterior lateral tooth (Fig. 11d). There are two lateral teeth, the posterior lateral more pronounced than the anterior, in both valves (Fig. 11c-d). The specimen is similar to plate 167 in COAN AND VALENTICH-SCOTT (2012), and had many eggs in the mantle cavity. The valves were broken along the ventral margin during identification.

Distribution: Only known from the type locality, El Salvador (COAN AND VALENTICH-SCOTT, 2012). This is the first record after the original description, therefore, new for the PNIC and Costa Rica.

Family UNGULINIDAE J. E. Gray, 1854
Genus *Diplodonta* Bronn, 1831

Diplodonta sp. (Figure 12 a-d, Code 54)

Material studied: Silverado: st. 2, d. 1, 9.5 m, 1 ind. – Bahía Chatham: st. 8, d. 1, 2.5 m, 1 ind; st. 9, d. 2, 10.1 m, 1 ind. Manuelita: st. 11, d. 1, 13.6 m, 1 ind; st. 11, d. 5, 16.6 m, 1 ind. – Bahía Weston: st. 13, d. 4, 42.2 m, 1 ind; st. 14, d. 1, 18.5 m, 1 ind; st. 14, d. 2, 17.4 m, 6 ind; st. 14, d. 3, 19.5 m, 2 ind; st. 14, d. 4, 18.6 m, 1 ind. – Bahía Wafer: st. 19, d. 1, 27.8 m, 1 ind. – Punta Gissler: st. 25, d. 5, 52.6 m, 1 ind.

Size: 1.3 × 1.4 – 1.3 × 1.7 mm.

Remarks: These were small juvenile, fragile, and translucent shells (Fig. 12a-b). The anterior end is longer, and the hinge has two cardinal teeth (Fig. 12c-d). The right valve has a narrow anterior cardinal in dorsal location, and the posterior cardinal is bifid (Fig. 12c). The left valve has the anterior cardinal bifid, and the posterior cardinal is narrow (Fig. 12d). Without lateral teeth. Fine radial lines and commarginal sculpture. All these characters as indicated by COAN AND VALENTICH-SCOTT (2012), for this genus, make us think that this is a juvenile of a species of the genus *Diplodonta*. It is possibly a new species, but more sampling is needed to collect grown juveniles and adults.

Distribution: There are eleven species in this genus reported for the mainland coast of Costa Rica (MAGAÑA-CUBILLO AND ESPINOSA, 2009; COAN AND VALENTISH-SCOTT, 2012), a single species in the Galapagos (FINET *ET AL.*, 2011) and two in Gorgona (UAESPNN, 2005, Appendix III).

Family SEMELIDAE Stoliczka, 1870 (1825)
Genus *Semele* Schumacher, 1817

Semele (*Amphidesma*) *formosa* (G.B. Sowerby I, 1833) (Figure 13, Code 55)

Amphidesma formosum G.B. Sowerby I, 1833, *Proc. Comm. Sc. Corresp. Zool. Soc. London*, 2: 199, pl. 4, Fig. 27.
Semele formosa (G.B. Sowerby I, 1833) – Keen, 1971: 251.
Semele (Amphidesma) formosa (G.B. Sowerby I, 1833) – Coan, 1988, *The Veliger*, 31: 17-18; Coan and Valentich-Scott 2012: 715, pl. 220.
Semele verruculastra Keen, 1966, *Occas. Papers California Acad. Sci.*, 59: 32-33.
Semele verrucosa Mörch, 1860 [misidentification] – Hertlein and Strong, 1949, *Zoologica: Sci. Contr. New York Zool. Soc*, 34 (4): 249, pl. 1, figs. 21, 24; Keen, 1958, *Sea shells trop. West Amer.*: 202, Fig. 504; Olsson, 1961, *Moll. Trop. East. Pac.*: 366, pl. 65, figs.1-lb; Hertlein and Emerson, 1964, *Trans. San Diego Soc. Nat. Hist.*, 13: 359, figs. 3 i, j.

Material studied: Bahía Wafer: st. 19, d. 3, 23.6m, 1 ind.

Size: 3.2 × 15.1 mm.

Remarks: The specimen of PNIC was similar to *Semele verruculastra* Keen, 1966, as in Fig. 653 of KEEN (1971); this is a synonym of *Semele formosa* (G.B. Sowerby I, 1833). The shell was yellow to dark cream in colour, with brown-purple maculations. The inequilateral valves have a sculpture of commarginal ribs forming scalelike projections at both extremes while in the middle they are continuous. Also, the shell has fine radial striae in the interspaces (KEEN, 1966; KEEN,1971; COAN AND VALENTICH-SCOTT, 2012).

Distribution: Reports of *S. verruculastra* are from Gulf of California to Panama Bay, and as *S. formosa* includes Ecuador (KEEN, 1971). Both forms were reported in Gorgona, but none occurs in Galapagos or Malpelo (UAESPNN, 2005, Appendix III; FINET *ET AL.*, 2011). *Semele formosa* was found previously in Costa Rica mainland and in Isla del Coco (INBIO, 1989; MAGAÑA-CUBILLO AND ESPINOSA, 2009).

Family TELLINIDAE Blainville, 1814
Genus *Tellina* Linnaeus, 1758

Tellina (*Moerella*) sp. (Figure 14, Code 56)

Material studied: Bahía Chatham: st. 4, d. 2, 34.8 m, 1 ind; st. 4, d. 3, 35.8 m, 1 ind. – Bahía Wafer: st. 19, d. 2, 24.7 m, 1 ind. – Punta Gissler: st.; st. 25, d. 5, 54.1 m, 1 ind.

Size: 0.4 × 1.0 – 1.0 × 2.0 mm.

Remarks: The valves are small and thin, white in color. The anterior end is more rounded and longer than the pointed posterior end. The specimens have very close commarginal ribs that become stronger posteriorly, and the ligament is conspicuous and external.

Distribution: Species of this sub genus were previously found in the Galapagos (FINET *ET AL.*, 2011) and from Gulf of California to Ecuador (KEEN, 1971; COAN AND VALENTICH-SCOTT, 2012) including the Costa Rica mainland (INBIO, 1989; MAGAÑA-CUBILLO AND ESPINOSA, 2009).

Tellina (*Moerella*) *coani* (Keen, 1971) (Figure 15 a-c, Code 57)

Tellina (*Angulus*) *coani* Keen, 1971: 211.
Tellina (*Moerella*) *coani* Keen, 1971 – Coan and Valentich-Scott, 2012: 649, Plate 199.

Material studied: Bahía Chatham: st. 4, d.1, 33.8 m, 1 ind; – Punta Gissler: st. 25, d. 3, 52.4 m, 1 ind.

Size: 2.6 × 4.5 mm.

Remarks: Shells are solid with the anterior end much longer, with commarginal sculpture, and orange coloration in these specimens (Fig. 15a). The internal side of the valves presented two

orange lines from beaks to ventral margin. The anterior lateral tooth is more developed in the right valve (Fig. 15b), and there are two cardinal teeth per valve (KEEN, 1971; COAN AND VALENTICH-SCOTT, 2012). The outline is comparable to Fig. 512 of KEEN (1971) and the internal lines pattern, shape and hinge to plate 199 of COAN AND VALENTICH-SCOTT (2012). These authors mentioned that specimens from Isla del Coco are colorful and smaller than individuals of the mainland.

Distribution: Gulf of California to Isla del Coco and Galapagos (COAN AND VALENTICH-SCOTT, 2012).

Tellina (*Laciolina*) sp. (Figure 16, Code 58)

Material studied: Bahía Weston: st. 15, d. 4, 12.3 m. 1 ind.

Size: 1.0 × 2.2 mm.

Remarks: *Tellina* (*Laciolina*) is the most similar in shape to the damaged juvenile specimen found, with a strong lateral tooth in the right valve (COAN AND VALENTICH-SCOTT, 2012). Sculpture of fine commarginal ribs, most marked in ventral margin. The valve differs in the outline from *T.* (*Moerella*) *amianta*, and *T.* (*M.*) *coani*. Other species of Tellinidae present in the sand bottom of Isla del Coco are *Tellina* (*Elliptotellina*) *pacifica* Dall, 1900, and *Tellina* (*Tellinella*) *cumingii* Hanley, 1844, but the first has heavy radial ribs and the latter shows large anterior and posterior ends (COAN AND VALENTICH-SCOTT, 2012).The species *Tellina* (*Laciolina*) *ochracea* P.P. Carpenter, 1864, is present in PNIC, but it is not possibly to atribute the present specimen to this species because of its damaged condition and juvenile stage.

Distribution: *Tellina* (*Laciolina*) *ochracea* is present from the Gulf of California to Isla del Coco and Galapagos, no other species of *Tellina* (*Laciolina*) are reported by COAN AND VALENTICH-SCOTT (2012).

Family VENERIDAE Rafinesque, 1815
Genus *Gouldia* C.B. Adams, 1847

Gouldia californica Dall, 1917 (Figure 17 a-j, Code 59)

Gouldia californica Dall, 1917, *Proc. U.S. Nat. Mus.*, 51: 579; Coan and Valentich-Scott, 2012: 786, Plate 243.

Material studied: El Arco: st. 1, d. 1, 58 m, 1 ind. – Slverado: st. 2, d. 1, 9.5 m, 2 ind; st. 2, d. 2, 9.5 m, 2 ind; st. 2, d. 4, 10.6 m, 1 ind; st. 2, d. 5, 9.6 m, 4 ind. – Punta Ulloa: st. 3, d. 1, 74 m, 1 ind. – Bahía Chatham: st. 4, d. 1, 33.8 m, 5 ind; st. 4, d. 2, 34.8 m, 15 ind; st. 4, d. 3, 35.8 m, 8 ind; st. 4, d. 4, 34.9 m, 13 ind; st. 4, d. 5, 34.9 m, 2 ind; st. 5, d. 1, 15.9 m, 15 ind; st. 5, d. 2, 16 m, 6 ind; st. 5, d. 3, 16 m, 14 ind; st. 5, d. 4, 16 m, 21 ind; st. 5, d. 5, 16.1 m, 16 ind; st. 6, d. 2, 9.2 m, 1 ind. – Manuelita: st. 11, d. 1, 13.6 m, 11 ind; st. 11, d. 2, 14.6 m, 8 ind; st. 11, d. 3, 14.6 m, 5 ind; st. 11, d. 4, 15.6 m, 3 ind; st. 11, d. 5, 16.6 m, 18 ind. – Bahía Weston: st. 13, d. 1, 41.9 m, 24 ind; st. 13, d. 2, 43 m, 7 ind; st. 13, d. 3, 41.1 m, 13 ind; st. 13, d. 4, 42.2 m, 6 ind; st. 13, d. 5, 42.3 m, 16 ind; st. 14, d. 1, 18.5 m, 3 ind; st. 14, d. 2, 17.4 m, 14 ind; st. 14, d. 3, 19.5 m, 10 ind; st. 14, d. 5, 18.6 m, 3 ind. – Bahía Wafer: st. 17, d. 2, 23.6 m, 2 ind; st. 19, d. 1, 27.8 m, 2 ind; st. 19, d. 4, 20.5 m, 1 ind; st. 20, d. 2, 39.1 m, 1 ind; st. 20, d. 4, 38.2 m, 1 ind. – Punta Gissler: st. 25, d. 3, 52.4 m, 1 ind. – Bahía Yglesias: st. 27, d. 1, 14 m, 1 ind; st. 27, d. 4, 13.6 m, 1 ind; st. 27, d. 5, 12.2 m, 1 ind.

Size: 3.0 × 3.0 –6.4 × 7.1 mm.

Remarks: The anterior lateral tooth is large and prominent (Fig. 17a); the lateral teeth and cardinal beaks are in a similar arrangement to that of plate 243 in COAN AND VALENTICH-SCOTT (2012).

Margins are smooth, the sculpture reticulate, with commarginal ribs prominent in the middle of the shell, and radial ribs prominent toward the ends of the valves (Fig. 17b, d-g). The pallial sinus is very small (Fig. 17b, h-j) (KEEN, 1971). The shell is extremely variable in the number of brown colour spots, and external colour ranges from cream to dark tan (Fig. 17b-g), and some juvenile are white (Fig. 17c)..

Distribution: From Gulf of California to Panama (KEEN, 1971). Previously in Pacific mainland of Costa Rica (INBIO, 1989; MAGAÑA-CUBILLO AND ESPINOSA, 2009), Galapagos (FINET *ET AL.*, 2011), and recently reported from Isla del Coco by COAN AND VALENTICH-SCOTT (2012).

Order ANOMALODESMATA Dall, 1889
Family VERTICORDIIDAE Stoliczka, 1870
Genus *Trigonulina* d'Orbigny, 1846

Trigonulina novemcostata (A. Adams and Reeve, 1850) (Figure 18 a-e, Code 60)

Hippagus novemcostatus A. Adams and Reeve, 1850, *Zool. Voy. Samarang*: 76.
Trigonulina novemcostata (A. Adams and Reeve, 1850) – Coan and Valentich-Scott, 2012: 1030, pl. 325.
Vericordia (*Trigonulina*) *hancocki* F.R. Bernard, 1969, *J. Fish. Res. Bd, Canada*, 26 (8): 2233.
Verticordia (*Verticordia*) *ornata* (d' Orbigny, 1846) [misidentification] – Keen, 1971: 302.
Trigonulina pacifica Jung, 1996, *Bull. Amer. Paleontol.*, 110 (351): 48-50, pl. 13-14.

Material studied: El Arco: st. 1, d. 2, 60.8 m, 1 ind. – Bahía Chatham: st. 3, d. 2, 73.9 m, 1 ind.

Size: 1.3 × 2.2 mm.

Remarks: *Trigonulina novemcostata* (A. Adams and Reeve, 1850) has an ovate shell and the valves are pearly within (Fig. 18c-d), similar to the individuals found. The specimens examined have 8-9 radial ribs (Fig. 18a-b). These bivalves are similar to Fig. 789 in KEEN (1971) as *Verticordia* (*Verticordia*) *ornata* (d' Orbigny, 1846), plate 13 and 14 of *Trigonulina pacifica* of Jung (1996), and plate 325 of *T. novemcostata* in COAN AND VALENTICH-SCOTT (2012), all species recognized as *T. novemcostata*. The surface of the valves is covered with rows of iridescent, scaly pustules (Fig. 18b). The hinge and teeth are as described by KEEN (1971), with no cardinal tooth in the left valve, and a posterior lateral tooth prolonged in the right valve (Fig. 18e) as pointed out by JUNG (1996) and COAN AND VALENTICH-SCOTT (2012).

Distribution: Distributed from California to Peru. The species was collected in Costa Rica mainland (INBIO, 1989), Galapagos (FINET *ET AL.*, 2011), and Isla del Coco (COAN AND VALENTICH-SCOTT, 2012). Previous records of *T. ornata* or *T. pacifica* from these islands corresponded to specimens of *T. novemcostata*, as pointed out by COAN AND VALENTICH-SCOTT (2012).

Class GASTROPODA Cuvier, 1797
Subclass VETIGASTROPODA Salvini-Plawen, 1980
Family PHASIANELLIDAE Swainson, 1840
Genus *Tricolia* Risso, 1826

Tricolia diantha McLean, 1970 (Figure 19 a-d, Code 79)

Tricolia diantha McLean, 1970, *Malac. Rev.*, 2: 125-126 – Keen 1971: 356.

Material studied: Bahía Wafer: st. 18, d. 5, 7.3 m. 1 ind.

Size: 0.5 × 1.0 mm.

Remarks: The small specimen found (Fig. 19a) has radial striae in the outer margin of the operculum (Fig. 19c). The shell has brown maculation in the last whorls (Fig. 19b), and presented fine sculpture in the brown early whorls, and fine spiral striae in the last whorl. The specimen is similar to the description in KEEN (1971). Another species reported in PNIC is *Tricolia variabilis* (Pease, 1861).

Distribution: Galapagos and Isla del Coco (KEEN, 1971, CORTÉS, 2012).

Subclass CAENOGASTROPODA Cox, 1960
Family EPITONIIDAE Berry, 1910
Genus *Epitonium* Röding, 1798

Epitonium replicatum (G.B. Sowerby II, 1844) (Figure 20, Code 61)

Scalaria replicata Sowerby, 1844, *Proc. Zool. Soc, London*, 1844: 11.
Epitonium (Hirtoscala) replicatum (G.B. Sowerby II, 1844) – Keen, 1971: 430.
Epitonium bialatum Dall, 1917, *Proc. U.S. Nat. Mus.*, 53 (2217): 417-88.
Epitonium wurtsbaughi Strong and Hertlein, 1939, *Allan Hancock Pac. Exp.*, 2: 177-245.
Epitonium arestrum Tinker, 1952, *Pacific sea shells*: 231.
Epitonium oerstedianum Hertlein and Strong, 1951, *Zoologica: Sci. Contr. New York Zool. Soc*, 36: 89, pl. 3 fig. 10.

Material studied: Bahía Weston: st. 13, d. 4, 42.2 m, 1 ind.

Size: 9.5 × 5.9 mm.

Remarks: The shell of *Epitonium replicatum* is shorter than other similar species in the Eastern Pacific such as *Epitonium reflexum* (Carpenter, 1856). White shell with costae strongly reflected, similar to Fig. 637 of gastropods in KEEN (1971).

Distribution: Gulf of California to Galapagos. The species is present in Costa Rica (INBIO, 1989; RODRÍGUEZ-SEVILLA, VARGAS AND CORTÉS, 2009) including the PNIC. Also, the species can be found in Galapagos and Gorgona (UAESPNN, 2005, APÉNDICE III; RODRÍGUEZ-SEVILLA *ET AL.*, 2009; FINET *ET AL.*, 2011).

Genus *Opalia* H. Adams and A. Adams, 1853

Opalia (*Dentiscala*) sp. (Figure 21, Code 62)

Material studied: Manuelita: st. 11, d. 1, 13.6 m, 1 ind.

Size: 3.4 × 1.4 mm.

Remarks: A small specimen, broken in their spire, is *Opalia* (*Dentiscala*) sp., and the most similar species is *Opalia* (*Dentiscala*) *mexicana* Dall, 1908, by the presence of deeper pits in the suture (Fig. 684 of KEEN, 1971). In contrast, the specimen of Isla del Coco presented a sculpture with marked punctuations between ribs, most angular shape, and their aperture is oval. The other species of the genus reported in Isla del Coco and the region (*Opalia crystallina* (Carpenter, 1864), *Opalia infrequens* (C.B. Adams, 1852), *Opalia paulula* DuShane, 1974, *Opalia sanjuanensis* (Lowe, 1932)), lack the deeper pits in the suture (KEEN, 1971; RODRÍGUEZ-SEVILLA *ET AL.*, 2009). The specimen possibly represents a new species but more material is needed.

Distribution: KEEN (1971), mentioned this species for Acapulco, Mexico, and also it was reported for Galapagos (FINET *ET AL.*, 2011).

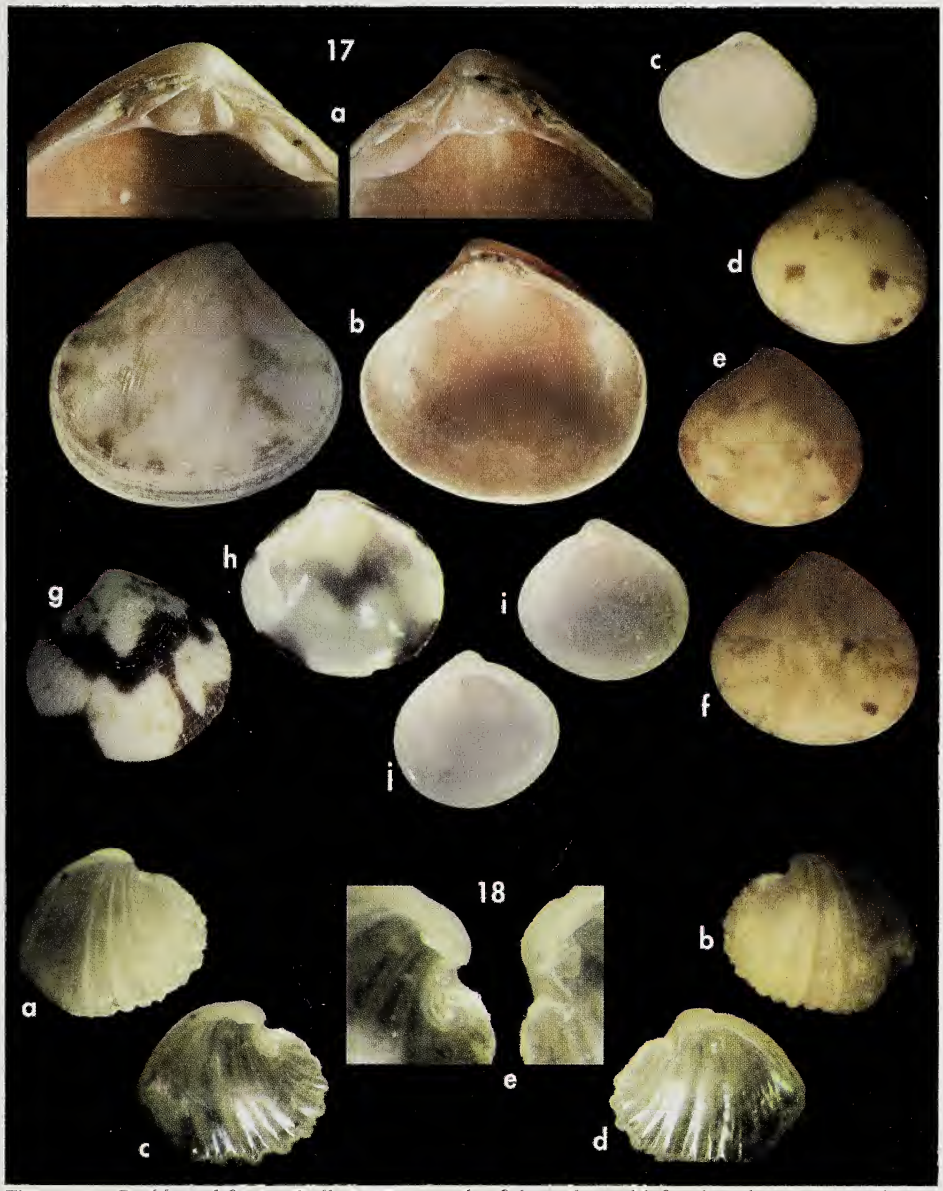

Figure 17. *Gouldia californica* Dall, 1917, a: teeth of the right and left valves; b: exterior and interior view of the valve of adult specimen; c-g: exterior view of the valves in small specimens; h-j: interior view of the valves in small specimens, 3.0 × 3.0 – 6.4 × 7.1 mm, st. 2 and 11. Figure 18. *Trigonulina novemcostata* (A. Adams and Reeve, 1850), a: exterior view of right valve; b: exterior of left valve; c: interior of left valve; d: interior of right valve; e: detail of the teeth in the left and right valves, 1.3 × 2.2 mm, st. 1.

Figura 17. Gouldia californica *Dall, 1917, a: dientes de las valvas derecha e izquierda; b: vista exterior e interior de la valva de un espécimen adulto; c-g: vista exterior de las valvas en especímenes pequeños; h-j: vista interior de the valvas en pequeños especímenes, 3,0 × 3,0 –6,4 × 7,1 mm, est. 2 y 11. Figura 18.* Trigonulina novemcostata *(A. Adams y Reeve, 1850), a: vista exterior de la valva derecha; b: exterior de la valva izquierda; c: interior de izquierda valva; d: interior de la valva derecha; e: detalle de los dientes en las the valvas izquierda y derecha, 1,3 × 2,2 mm, est. 1.*

Orden LITTORINIMORPHA Golikov and Starobogatov, 1975
Family RISSOIDAE Gray, 1847
Genus *Schwartziella* G. Nevill, 1885

Schwartziella effusa (Mörch, 1860) (Figure 22, Code 67)

Rissoina effusa Mørch, 1860, *Malakozool. Blätter*, 7: 67-68.
Rissoina (*Rissoina*) *effusa* Mörch, 1860 – Keen, 1971: 374.
Schwartziella effusa (Mörch, 1860) – Sleurs, 1989, *Ann. Soc. Roy. Zool. Belgique*, 119 (2): 155-164.

Material studied: Bahía Wafer: st. 19, d. 5, 24.4 m, 1 ind.

Size: 3.3 × 2.1 mm.

Remarks: This small snail found in this study in a small rhodolith, in the sand bottom, resembles the specimen shown in Fig. 25 of KEEN (1966). *Schwartziella effusa* has 12 to 15 oblique axial ribs, compressed and thick, in a heavy shell (KEEN, 1966). The outer margin of the aperture is thin (MÖRCH, 1860).

Distribution: Along Central American Pacific coast, Malpelo, Galapagos, and previously in Isla del Coco (KEEN, 1971; INBIO, 1989; UAESPNN, 2005, APÉNDICE III; RODRÍGUEZ-SEVILLA *ET AL.*, 2009; FINET *ET AL.*, 2011).

Genus *Alvania* Risso, 1826

Alvania sp. (Fig. 23, Code 68)

Material studied: Punta Gissler: st. 26, d. 2, 12.1 m, 1 ind.

Size: 2.6 × 1.0 mm.

Observations: This small gastropod resembles species of the genus *Alvania*, in terms of shape, spiral ribs and weak radial cords (KEEN, 1971).

Distribution: *Alvania inconspicua* C.B. Adams, 1852 (= *A. monserratensis* Baker, Hanna & Strong, 1930) has been reported from Isla del Coco (RODRÍGUEZ-SEVILLA *ET AL.*, 2009) but it is a very different species.

Family CAECIDAE Gray, 1850
Genus *Caecum* Fleming, 1813

Caecum cocoensis spec. nov. (Fig. 24 a-n, Code 63)

Type material: Holotype: Silverado: st. 2, d. 2, 9.5 m, 1 ind, Catalog number: MZUCR9740-01; Paratype: Silverado: st. 2, d. 5, 9.6 m, 1 ind. Catalog number: MZUCR9741-01; Paratype: Punta Gissler: st. 26, d. 1, 13.1 m, 1 ind. Catalog number: MZUCR9742-01
Additional material: Bahía Yglesias: st. 27, d. 1, 14 m, 1 ind.
Type locality: Silverado, Parque Nacional Isla del Coco, Costa Rica.
Derivation of the name: This species name is based on the type locality, Isla del Coco.

Description: Shell length: 2.10 mm ±0.20; width min: 0.47 mm ± 0.01, and width max: 0.50 mm ± 0.03. The shell is slightly arched and translucent, with some tan colour (Fig. 24a). The form of the septum is mammillate, tapering, and constant (Fig. 24g-j). There is no mucro present in the specimens collected. The sculpture is formed by rings more widely spaced and well marked distaly, becoming near the aperture narrower and less well-marked. The shell presented some porosity with minute holes in the rings and marked pits in the inter

Figure 19. *Tricolia diantha* McLean, 1970, a: aperture view; b: operculum detail; c: view of the sculpture and coloration, d: first whorls, 0.5 × 1.0 mm, st. 18. Figure 20. *Epitonium replicatum* (G. B. Sowerby II, 1844), 9.5 × 5.9 mm, st. 13. Figure 21. *Opalia* (*Dentiscala*) sp., 3.4 × 1.4 mm, st. 11. Figure 22. *Schwartziella effusa* (Mörch, 1860), 3.3 × 2.1 mm, st. 19. Figure 23. *Alvania* sp., 2.6 × 1.0 mm, st. 26.

Figura 19. Tricolia diantha *McLean, 1970, a: vista de la apertura; b: detalle del opérculo; c: vista de la escultura y coloración, d: primeras vueltas, 0,5 × 1,0 mm, est. 18. Figura 20.* Epitonium replicatum *(G. B. Sowerby II, 1844), 9,5 × 5,9 mm, est. 13. Figura 21.* Opalia (Dentiscala) *sp., 3,4 × 1,4 mm, est. 11. Figura 22.* Schwartziella effusa *(Mörch, 1860), 3,3 × 2,1 mm, est. 19. Figura 23.* Alvania *sp., 2,6 × 1,0 mm, est. 26.*

ring spaces (Fig. 24l-n). Moreover, subadult traits are present in some sections of the tube of the specimens, where the ringed sculpture appears to be interrupted by incised lines (Fig. 24d, e, k, m), representing a transitional zone between the teleoconch growth stages. The aperture is smooth and underdeveloped, another indication of a subadult stage; and the operculum is brown, flat, and presents a heavy concentric sculpture (Fig. 24b, c, f). Finally a hole or deep depression is present in the septum of the specimens (Fig. 24g-j).

Remarks: Four subadult individuals were found of a new species of the genus *Caecum*. The specimen of st. 27, d. 1, was dissected to extract the operculum. The specimens of st. 2, d. 2, and st. 2, d. 5, were used in SEM photos, frontal and lateral view, respectively.

The species *Caecum glabriforme* Carpenter, 1857 is reported from the Costa Rica mainland (INBIO, 1989; RODRÍGUEZ-SEVILLA *ET AL.*, 2009), Malpelo, and Panamá (KEEN, 1971) and shows a septum much more swollen in adult specimens as in figure 374-1546 of BRANN

(1966). Moreover, *C. glabriforme* has a smooth surface and lacks rings (KEEN, 1971) but in specimens of *C. cocoensis* found in PNIC, the sculpture is well marked. Other species present in Isla del Coco and Galapagos (e.g. *Caecum eburneum* C. B. Adams, 1852), have very coarse rings but with an ungulate or mucronate septum (LIGHTFOOT, 1993a, 1993b). The sculpture pattern of *Caecum eburneum* C.B. Adams [not de Folin, 1879] in plate 17, Fig. 3 of TURNER (1956) is clearly different from the species found in Isla del Coco. The mammillate shape and tapering of the septum of the new species is very similar to *Caecum subquadratum* Carpenter, 1859, as well as to *Caecum venustum* de Folin, 1867 (West Panama), but both species lack the marked ringed sculpture. To sumarize, the specimens of *C. cocoensis* by the combination of a mammilate septum and marked ringed sculpture are not similar to the other species in the Tropical Eastern Pacific (KEEN, 1971; LIGHTFOOT, 1993A; LIGHTFOOT, 1993B; KAISER AND BRYCE, 2001; KAISER, 2007; MCLEAN, 2007; PIZZINI, RAINES AND NOFRONI, 2007).

Distribution: Only found in Isla del Coco, Costa Rica in the present study.

Family NATICIDAE Forbes, 1838
Genus *Natica* Scopoli, 1777

Natica idiopoma Pilsbry and Lowe, 1932 (Fig. 25, Code 64)

Natica idiopoma Pilsbry and Lowe, 1932, *Proc. Acad. Nat. Sci.*, 84: 84. pl. 9, Fig. 9-11.
Natica (*Natica*) *idiopoma* Pilsbry and Lowe, 1932 – Keen, 1971: 475.

Material studied: Bahía Weston: st. 13, d. 2, 43 m, 1 ind.
Size: 5.0 × 6.5 mm.

Remarks: This snail is characterized by having three spiral ribs in the operculum (Fig. 864 in KEEN, 1971), the outer rib is doubled and bound by radial rods (PILSBRY AND LOWE, 1932; KEEN, 1971). The umbilicus is open, with a small callus next to the middle inner lip. The shell is brown and whitish.

Distribution: Previously known for the Pacific of Nicaragua and Costa Rica, Isla del Coco, Galapagos, and Gorgona (KEEN, 1971; UAESPNN, 2005, Apéndice III; RODRÍGUEZ-SEVILLA *ET AL.*, 2009; FINET *ET AL.*, 2011).

Genus *Natica* Scopoli, 1777

Natica grayi Philippi, 1852 (Fig. 26, Code 65)

Natica depressa Gray, 1839: *Zool. Capt. Beechey's Voy.*, 136, pl. 36 fig. 2 (preoccupied name).
Natica catenata Phillipi, 1851, *Proc. Zool. Soc. London*, 19: 233; Philippi, 1852, *Syst. Conch.-Cab. Martini und Chemnitz*, 2 (1): 130, nº 153, t 18, Fig. 11.
Natica grayi Philippi, 1852, *Syst. Conch.-Cab. Martini und Chemnitz*, 2 (1): 74-75, nº 88, pl 11 Fig. 13.

Material studied: Punta Gissler: st. 25, d. 3, 52.4 m, 1 ind.
Size: 5.9 × 4.7 mm.

Remarks: This brown snail has a white operculum with radial laminations, and a characteristic outer groove. Our specimen is similar to Fig. 863 in KEEN (1971) for *Natica grayi* Philippi, 1852.

Distribution: Gulf of California to Ecuador. The species was previously found in Isla del Coco, Galapagos, Gorgona (KEEN, 1971; UAESPNN, 2005, APÉNDICE III; RODRÍGUEZ-SEVILLA *ET AL.*, 2009; FINET *ET AL.*, 2011).

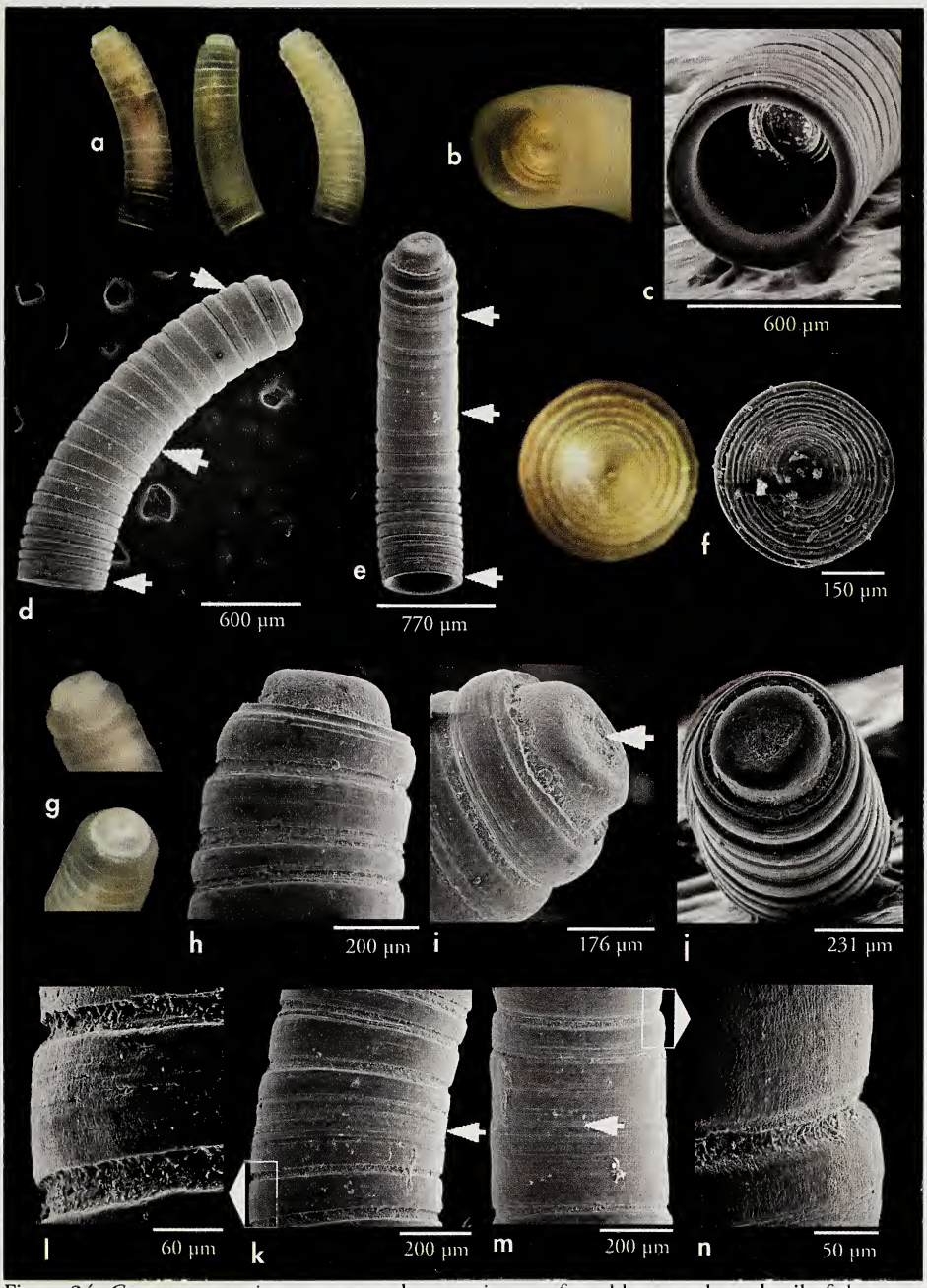

Figure 24. *Caecum cocoensis* spec. nov. a, d, e: specimens of sand bottom; b, c: detail of the aperture; f: operculum; g-j: detail apical end; k, m: detail of the rings sculpture; l, n: detail of the pits in the surface and interspaces of the rings, st. 2, 26 and 27. The arrows indicate subadult traits.

Figura 24. Caecum cocoensis *spec. nov. a, d, e: especímenes del fondo arenoso; b, c: detalle de la apertura; f: opérculo; g-j: detalle de la región apical; k, m: detalle de los anillos de la escultura; l, n: detalle de los hoyos en las superficie y entre los anillos, est. 2, 26 y 27. Las flechas indican características del estado sub-adulto.*

Genus *Mammilla* Schumacher, 1817

Mammilla simiae (Deshayes, 1838) (Fig. 27, Code 66)

Natica sigaretina Menke, 1828, *Synops. Moll. Mus. Menkeano*: 26 (preoccupied name).
Natica simiae Deshayes, 1838, *Hist. Nat. Anim. sans Vert.*: 652; Philippi, 1852: *Syst. Conch.-Cab. Martini und Chemnitz*, 2 (1): 35, pl. 4 Fig. 17; Reeve, 1855, *Conch. Icon.*, 9: pl. 17 figs. 76a, b; pl. 22, figs. 98a, b; Tryon, 1886, *Man. Conch.*, 8: 51, pl. 21 figs. 19-20.
Mammilla simiae (Deshayes, 1838) – Kabat, 2000, *Zool. Mededelingen*, 73 (25): 357.
Polinices simiae (Deshayes, 1838) – Kay, 1979, *Hawaiian Mar. Sh.*: 210, figs. 73G, H.
Polinices (*Mammilla*) *simiae* (Deshayes, 1838); Cernohorsky, 1971, *Rec.Auckland Inst. Mus.* 8: 199, Fig. 68; Cernohorsky, 1972, *Mar. Sh. Pacific*: 102, pl. 27 Fig. 2; Powell, 1979, *New Zeal. Moll.*: 156, pl. 32 figs. 14, 15.
Natica samarensis Récluz, 1844: 214; Philippi, 1853, *Syst. Conch.-Cab. Martini und Chemnitz*, 2 (1): 149.
Mammilla propesimiae Iredale, 1929, *Austr. Zool.* 5 (4): 340, pl. 38 fig. 5.

Material studied: Bahía Yglesias: st. 27, d. 5, 12.2 m, 1 ind.

Size: 5.5 × 6.1 mm.

Remarks: The shell is white with broken axial lines, forming irregular maculations (Kabat, 2000). The specimen of PNIC is a juvenile, characterized by the color of the protoconch and the dark line that borders the suture of the last whorls of this species (Chaney, 1996). The specimen found is similar to the immature specimens of Panama and West Pacific (Chaney, 1996; Hollmamm, 1996). The callus is prominent and tongue-shaped. The umbilicus has a brown line running into it from the base. The aperture is white inside, and the species has a horny operculum, reddish-brown in color (Hollmamm, 1996).

Distribution: The distribution is mainly in the West Pacific (Kabat, 2000), but it occurs in Hawaii and has been found in Clipperton, and Isla del Coco. The species is apparently absent from the Galapagos (Finet et al., 2011) and Pacific mainland except for Isla Ladrones, Gulf of Chiriqui, Panama (Chaney, 1996; Kabat, 2000). The first specimen in PNIC was collected in Isla Nuez (Isla Manuelita), at 55-91 m on rocky and coralline substrate by the Allan Hancock Expedition of *Velero III* in 1938. Shasky found the species on sand bottom in Isla Manuelita at 17 m in 1986 and in Bahía Chatham at 20-25 m in 1989. Kim Hutsell found it in sand bottom at 15-20 m in Bahía Wafer in 1992. All of these specimens were identified by Hollmamm (1996).

Family Ranellidae Gray, 1854
Monoplex Perry, 1810

Monoplex sp. (Fig. 28 a-c, Code 69)

Material studied: Bahía Chatham: st. 9, d. 1, 10.2 m; 1 ind. – Bahía Wafer: st. 18, d. 5, 7.3 m, 1 ind. – Bahía Yglesias: st. 27, d. 4, 13.6 m, 1 ind.

Size: 2.4 × 1.1 mm.

Remarks: The specimens found are larval stage of a ranellid, of the genus *Monoplex*. These large protoconchs are smooth orange with the early whorls with some radial sculpture (Fig. 28 b). The shape of the aperture is elongated (Fig. 28 a). It may possibly correspond to *Monoplex aquatilis* (Reeve, 1844), present in Isla del Coco (Cortés 2012).

Distribution: There are nine species of this group in Isla del Coco (Cortés 2012).

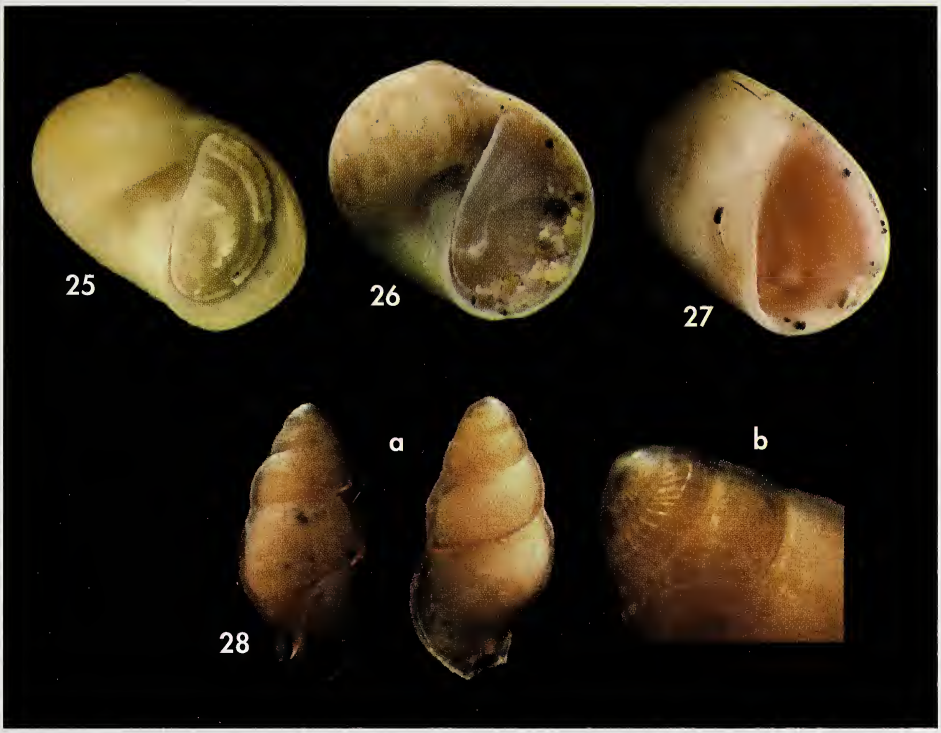

Figure 25. *Natica idiopoma* Pilsbry and Lowe, 1932, 5.0 × 6.5 mm, st. 13. Figure 26. *Natica grayi* Philippi, 1852, 5.9 × 4.7 mm, st. 25. Figure 27. *Mammilla simiae* (Deshayes, 1838), 5.5 × 6.1 mm, st. 27. Figure 28. *Monoplex* sp., a,b: larval stage, 2.4 × 1.1 mm, st. 9.
Figura 25. Natica idiopoma *Pilsbry y Lowe, 1932, 5,0 × 6,5 mm, est. 13. Figura 26.* Natica grayi *Philippi, 1852, 5,9 × 4,7 mm, est. 25. Figura 27.* Mammilla simiae *(Deshayes, 1838), 5.5 × 6.1 mm, est. 27. Figura 28.* Monoplex *sp., a, b: concha larvaria, 2,4 × 1,1 mm, est. 9.*

Family BUCCINIDAE Rafinesque, 1815
Genus *Phos* Montfort, 1810

Phos (Metaphos) articulatus Hinds, 1844 (Fig. 29, Code 70)

Phos articulatus Hinds, 1844, *Zool. Voy. "Sulphur"*: 38, pl. 10, Fig. 7 and 8.
Phos (Metaphos) articulatus Hinds, 1844 – Keen, 1971: 569.
Phos cocosensis Dall, 1896, *Proc. U. S. Nat. Mus.*, 18: 11.

Material studied: Bahía Chatham: st. 3, d. 5, 75.3 m, 2 ind.

Size: 39.8 × 16.1 mm.

Remarks: The shell is clouded with brown, has marked axial ribs and a spiral sculpture of several sharp striae. The aperture is longer than wide, and the outer lip is internally lirate. The operculum is horny, smooth-edged and red in colour (DALL, 1896; KEEN, 1971). Similar to some specimens showed in Fig. 1144 of KEEN (1971) of *Phos (Metaphos) articulatus* Hinds, 1844.

Distribution: From California to Perú, also present in Isla del Coco and Galapagos (KEEN, 1971; RODRÍGUEZ-SEVILLA *ET AL.*, 2009; FINET *ET AL.*, 2011).

Family Cystiscidae Stimpson, 1865
Genus *Gibberula* Swainson, 1840

Gibberula achenea (Roth and Coan, 1971) (Fig. 30, Code 71)

Granula achenea, Roth and Coan, 1971, *Proc. Cal. Acad. Sci.*, 37: 578-580. Fig. 3.

Material studied: Bahía Chatham: st. 4, d. 2, 34.8 m, 1 ind; st. 6, d. 2, 9.2 m, 1 ind.

Size: 2.2 × 1.7 mm.

Remarks: Coovert and Coovert, 1995 placed *Granula* Jousseaume, 1875 in synonymy of *Gibberula* Swainson, 1840. The shell is small and white, almost transparent, unsculptured, but with a surface ornamentation of fine lines uncommon in this family. The outer lip has tiny denticles inside the aperture as in Fig. 1412 in Keen (1971) of an unnamed *Granula* of Isla del Coco, later described as *Granula achenea*, Roth and Coan, 1971. Several characters of the specimens match this species; moreover, they show dark spots on the mantle in the preserved material.

Distribution: The first specimen was collected in Bahía Chatham by Pilsbry in 1929, also during the President Cruise expedition in 1938, and Waldo L. Schimitt, collected more specimens in 1941. Roth and Coan (1971) point out that *G. achenea* is common in Isla del Coco, and they questioned the presence in the island of *G. minor* (C.B. Adams, 1852), as possibly a misidentification of *G. achenea* specimens. Reported from Isla del Coco and Galapagos (Roth and Coan, 1971; Finet *et al.*, 2011).

Gibberula cf. *insularum* (Roth and Coan, 1971) (Fig. 31 a-b, Code 72)

Granula insularum, Roth and Coan, 1971, *Proc. Cal. Acad. Sci.*, 37: 580-582. Fig. 4.

Material studied: Bahía Chatham: st. 4, d. 3, 35.8 m, 1 ind. – Manuelita: st. 11, d. 1, 13.6 m, 2 ind; st. 11, d. 3, 14.6 m, 1 ind.

Size: 2.6 × 1.1 mm.

Remarks: The species is similar to *G. achenea* but lacks the ornamentation on the shell. It differs from *G. minor* and *G. polita* (Carpenter, 1857) in that the outer lip is smooth in *G. insularum* while in *G. minor* it is conspicuously denticulate and in *G. polita*, faintly denticulate. Additionally, *G. minor* is almost conical, while *G. insularum* is elongate-ovate. The living specimens found do not show a dark spot on the mantle as *G. achenea*. Figure 1413 in Keen (1971) corresponds to *G. insularum* in Fig. 4 of Roth and Coan (1971).

Distribution: Previously only known from the Galapagos Islands (Roth and Coan, 1971). The species is a new record for Isla del Coco.

Family Mitridae Swainson, 1829
Genus *Subcancilla* Olsson and Harbison, 1953

Subcancilla sulcata (Swainson in Sowerby, 1825) (Fig. 32, Code 74)

Mitra sulcata Swainson in Sowerby, 1825, *Cat. Tankerville*: App. xxvi.
Mitra (*Subcancilla*) *sulcata* (Swainson in Sowerby, 1825) – Olsson and Harbison, 1953, *Acad. Nat. Sci. Phil. Monogr.*, 8: 190.
Subcancilla sulcata (Swainson in Sowerby, 1825) – Keen, 1971. 645; Cernohorsky, 1991, *Monogr. Mar. Mol.*, 4: 86.

Material studied: Bahía Chatham: st. 4, d. 3, 35.8 m, 2 ind. – Bahía Weston: st. 13, d. 1, 41.9 m, 1 ind; st. 13, d. 3, 41.1 m, 1 ind. – Bahía Wafer: st. 17, d. 3, 27.6 m, 1 ind; st. 20, d. 3, 38.1 m, 1 ind.

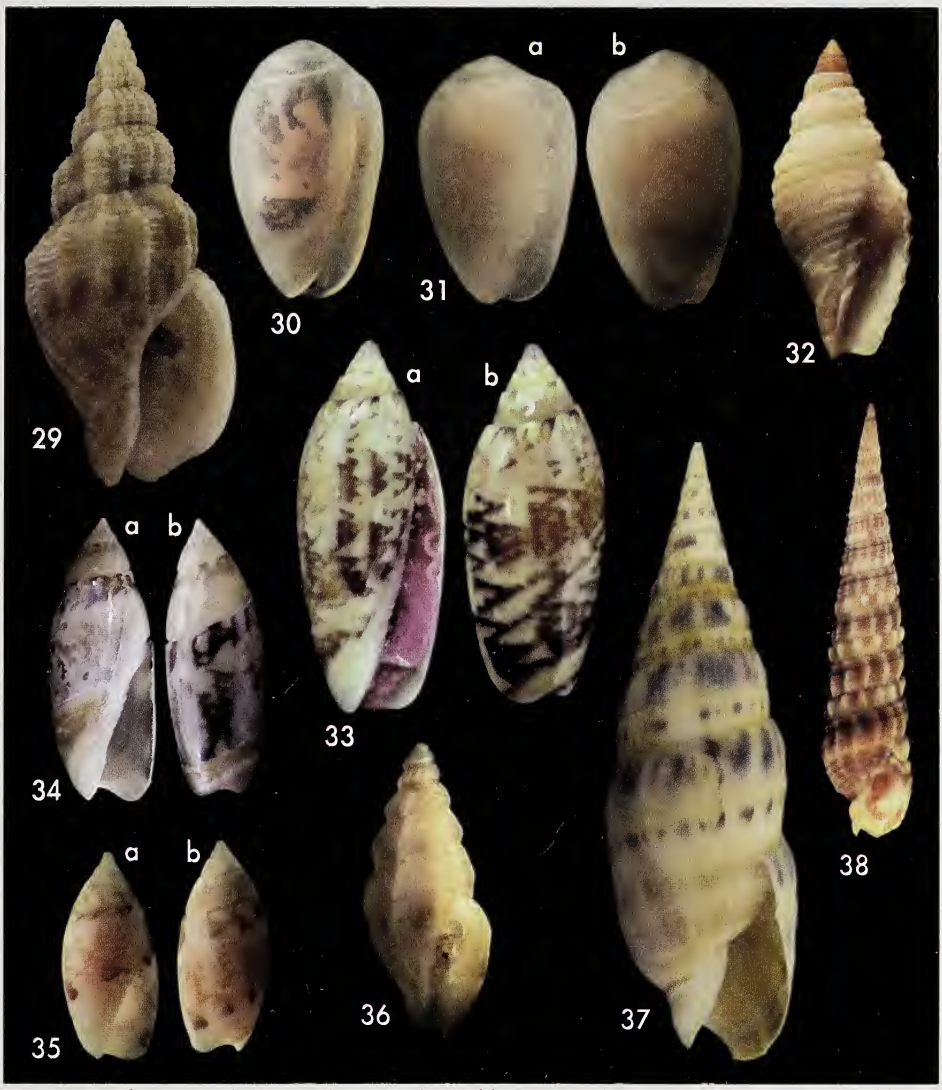

Figure 29. *Phos* (*Metaphos*) *articulatus* Hinds, 1844, 39.8 × 16.1 mm, st. 3. Figure 30. *Gibberula achenea* (Roth and Coan, 1971), 2.2 × 1.7 mm, st. 4. Figure 31 a, b. *Gibberula* cf. *insularum* (Roth and Coan, 1971), 2.6 × 1.1 mm, st. 11. Figure 32. *Subcancilla sulcata* (Swainson en Sowerby, 1825), 18.8 × 7.1 mm, st. 4. Figure 33 a, b. *Oliva foxi* Stingley, 1984, 20.6 × 10.5 mm, st. 1. Figure 34 a, b. *Olivella* (*Olivella*) *cocosensis* Olsson, 1956, adult, 12.2 × 4.4 mm, st. 2. Figure 35 a, b. O.(O) cocoensis Olsson, 1956, juvenile, st. 2. Figure 36. *Ithycythara penelope* (Dall, 1919), 3.6 × 1.4 mm, st. 4. Figure 37. *Oxymeris maculata* (Linnaeus, 1758), 90.0 × 26.2 mm, st. 11. Figure 38. *Pristiterebra glauca* (Hinds, 1844), 25.3 × 4.6 mm, st. 4.

Figura 29. Phos (Metaphos) articulatus *Hinds, 1844, 39,8 × 16,1 mm, est. 3. Figura 30.* Gibberula achenea *(Roth y Coan, 1971), 2,2 × 1,7 mm, est. 4. Figura 31 a, b.* Gibberula *cf.* insularum *(Roth y Coan, 1971), 2,6 × 1,1 mm, est. 11. Figure 32.* Subcancilla sulcata *(Swainson en Sowerby, 1825), 18,8 × 7,1 mm, est. 4. Figure 33 a, b.* Oliva foxi *Stingley, 1984, 20,6 × 10,5 mm, est. 1. Figura 34 a, b.* Olivella (Olivella) cocosensis *Olsson, 1956, adulto, 12,2 × 4,4 mm, est. 2. Figura 35 a, b.* O.(O) cocoensis *Olsson, 1956, juvenil, est. 2. Figura 36.* Ithycythara penelope *(Dall, 1919), 3,6 × 1,4 mm, est. 4. Figura 37.* Oxymeris maculata *(Linnaeus, 1758), 90,0 × 26,2 mm, est. 11. Figura 38.* Pristiterebra glauca *(Hinds, 1844), 25,3 × 4,6 mm, est. 4.*

Size: 6.4 × 2.0 - 18.8 × 7.1 mm.

Remarks: The shell is white to light brown, crossed by deeply impressed striae, with colorless spiral ribs (KEEN, 1971). The aperture is longer than the spire (SOWERBY, 1825).

Distribution: From California to Ecuador. The species was previously reported for Isla del Coco, Gorgona, and Galapagos (INBIO, 1989; UAESPNN, 2005, Apéndice III; RODRÍGUEZ-SEVILLA *ET AL.*, 2009; FINET *ET AL.*, 2011).

Family OLIVIDAE Latreille, 1825
Genus *Oliva* Bruguière, 1789

Oliva foxi Stingley, 1984 (Fig. 33 a-b, Code 75)

Oliva foxi Stingley, 1984, *La Conchiglia*, 16: 28.

Material studied: El Arco: st. 1, d. 1, 58 m, 1 ind.

Size: 20.6 × 10.5 mm.

Remarks: A single specimen found, similar to the picture of shells of Isla del Coco in SHASKY (1984) and STERBA (2003). Shell is smooth and glossy, oblong-cylindrical, and with spire acuminate. Color yellow with bold and weak zig zag markings of dark brown. The aperture is yellow (STINGLEY, 1984; SHASKY, 1984), and the protoconch is pink (STERBA, 2003).

Distribution: The species *Oliva foxi* Stingley, 1984 was discovered for the first time by Alfred C. and Eva Fox, by dredging and scuba diving between 50-60 feet off Isla del Coco, Costa Rica (STINGLEY, 1984). SHASKY (1984) re-described it with 21 specimens of Isla del Coco. *O. foxi* was considered endemic to Isla del Coco, Costa Rica, however KAISER (1999) mentioned their occurrence in Isla Montuosa, Panamá. There is no record for the Pacific mainland coast of America.

Genus *Olivella* Swainson, 1831

Olivella (*Olivella*) *cocosensis* Olsson, 1956 (Fig. 34 a-b, 35 a-b, Code 76)

Olivella (*Olivella*) *cocosensis* Olsson, 1956, *Proc. Acad. Nat. Phil.*, 108: 180, pl. 14, fig 9 and 9a.

Material studied: Silverado: st. 2, d. 2, 9.5 m, 3 ind; st. 2, d. 2, 9.5 m, 3 ind. – Bahía Chatham: st. 9, d. 1, 10.2 m, 1 ind; st. 9, d. 5, 9.9 m, 1 ind; st. 11, d. 1, 13.6 m, 2 ind. – Manuelita: st. 11, d. 4, 15.6 m, 1 ind; st. 11, d. 5, 16.6 m, 1 ind; st. 11, d. 5, 16.6 m, 1 ind. – Bahía Weston: st. 14, d. 2, 17.4 m, 2 ind; st. 15, d. 3, 12.3 m, 1 ind. – Bahía Wafer: st. 19, d. 3, 23.6 m, 1 ind. – Punta Gissler: st. 24, d. 4, 15 m, 2 ind; st. 26, d. 3, 12.2 m, 1 ind; st. 26, d. 5, 13.4 m, 2 ind. – Bahía Yglesias: st. 27, d. 2, 9.9 m, 1 ind; st. 27, d. 4, 13.6 m, 1 ind; st. 27, d. 5, 12.2 m, 1 ind.

Size: 2.3 × 0.8 – 12.2 × 4.4 mm.

Remarks: The species was found as adults (Fig. 34), and juvenile stage specimens (Fig. 35). This *Olivella* is common in the sand bottom of the island. STERBA (2003) mentioned the coloration and a distinctive grove in the inner lip that matches the specimens found. The pattern of coloration is white ground with amounts of brown suffusion (SHASKY, 1984). This olive snail has an upper dark band bordering the suture and a lower dark band bordering the fasciole (OLSSON, 1956). The white porcellaneous section of the inner lip extends near the suture of the last whorl as in figures 9 and 9a of OLSSON (1956). This snail has a shorter spire.

Distribution: The main population is in Isla del Coco, but other specimens were reported in North Nicaragua (KEEN, 1971).

Family MANGELIIDAE P. Fischer, 1883
Genus *Ithycythara* Woodring, 1928

Ithycythara penelope (Dall, 1919) (Fig. 36, Code 73)

Cytharella (*Agathotoma*) *penelope* Dall, 1919, *Proc. U.S. Nat Mus.*, 56: 80, pl. 24, Fig. 10.
Ithycythara penelope (Dall, 1919) – Keen 1971: 758.

Material studied: Bahía Chatham: st. 4, d. 2, 34.8 m, 1 ind; st. 4, d. 3, 35.8 m, 1 ind. – Punta Gissler: st. 25, d. 5, 54.1 m, 1 ind.

Size: 3.6 × 1.4 mm.

Remarks: The shell is hexagonal in section, pale brownish. Spiral sculpture consists of fine close-set threads over the entire surface. The aperture is narrow. This is the only Eastern Pacific Mangeliidae with dentate outer lip (KEEN, 1971).

Distribution: Present from California to Ecuador (KEEN, 1971). The species has been previously collected in Pacific Costa Rica, Isla del Coco, and Galapagos (INBIO, 1989; RODRÍGUEZ-SEVILLA *ET AL.*, 2009; FINET *ET AL.*, 2011).

Family TEREBRIDAE Mörch, 1852
Genus *Oxymeris* Dall, 1903

Oxymeris maculata (Linnaeus, 1758) (Fig. 37, Code 77)

Buccinum maculatum Linnaeus, 1758: *Syst. Nat., ed. 10*: 741
Terebra maculata (Linnaeus, 1758) – Kiener. 1834. *Spec. Gen. Icon. Coq. Viv.* 9: 4, pl. 1; Bratcher and Cernohorsky, 1987, *Living Terebras of the World*: 644, pl. 5, fig. 15a-c.
Terebra maculata maculata (Linnaeus, 1758) – Keen 1971: 680 [specimens of Isla del Coco].
Oxymeris maculata (Linnaeus, 1758) – Habe and Kosuge, 1967, *Stand. Book, Jap. Shell* col. 3: 102, pl. 40, Fig. 21.

Material studied: Silverado: st. 2, d. 1, 9.5 m, 1 ind. – Manuelita: st. 11, d. 3, 14.6 m, 1 ind.

Size: 14.5 × 5.4 – 90.0 × 26.2 mm.

Remarks: The specimens are a juvenile and an adult. The shell is similar to Fig. 1549 of Keen 1971 of a specimen from Isla del Coco. The coloration is dark cream with brown color spots. Spiral sculpture is absent. The species does not have axial ribs on later whorls. The shell can reach a large size ~20 cm, as was observed during some dives in Bahía Chatham.

Distribution: This species has an Indo and Central Pacific distribution (BRATCHER AND CERNOHORSKY, 1987), and is reported only in Clipperton and Isla del Coco, in the Eastern Pacific (KEEN, 1971; MONTOYA AND KAISER, 1988); the record from Clipperton is spurious (see KAYSER, 2007).

Genus *Pristiterebra* Taki and Oyama, 1954

Pristiterebra glauca (Hinds, 1844) (Fig. 38, Code 78)

Terebra aspera Hinds, 1844, *Proc. Zool. Soc. London, 1843 (11)*: 154 (preoccupied name).
Terebra radula Hinds, 1844, *Proc. Zool. Soc. London, 1843 (11)*: 155 (preoccupied name).
Terebra glauca Hinds, 1844, *Proc. Zool. Soc. London, 1843 (11)*: 155.
Pristiterebra glauca (Hinds, 1844) – Bratcher and Cernohorsky, 1987, *Living Terebras of the World*: 133/147; Terryn, 2007, *Terebridae*: 26; pl. 38 figs 5-6; pl. 58.
Terebra petiveriana Deshayes, 1857, *J. Conchyl.*, 6: 85, pl.5, Fig. 10.
Terebra dorothyae Bratcher and Burch, 1970, *The Veliger*, 12: 297.

Material studied: Bahía Chatham: st. 4, d. 1, 33.8 m, 1 ind; st. 4, d. 2, 34.8 m, 2 ind; st. 4, d. 3, 35.8 m, 2 ind; st. 4, d. 4, 34.9 m, 1 ind; st. 10, d. 2, 10.5 m, 1 ind; st. 10, d. 3, 10.6 m, 1 ind. – Bahía Weston: st. 15, d. 2, 12.2 m, 1 ind. – Bahía Wafer: st. 18, d. 2, 8.5 m, 1 ind; st. 18, d. 3, 7.4 m, 1 ind; st. 18, d. 5, 7.3 m, 1 ind; st. 20, d. 1, 44 m, 1 ind; st. 20, d. 3, 38.1 m, 1 ind. – Punta Gissler: st. 24, d. 4, 15 m, 1 ind; st. 25, d. 3, 52.4 m, 1 ind; st. 25, d. 5, 54.1 m, 1 ind.

Size: 3.4 × 1.0 – 25.3 × 4.6 mm.

Remarks: The suture with whitish tuberculate belt that is disposed in the shape of axial ribs. Moreover, a variety of coloration was found. Many specimens are dark brown, and other presented mostly pale coloration. The juveniles are mainly beige. Keen (1971) points out that this is the most variable terebrid of the Panamic province. The anterior canal is broad, short and recurved. The protoconch is coloured pink.

Distribution: From California to Ecuador, Pacific Costa Rica, the species was previously reported for PNIC and Galapagos, and Gorgona (Keen, 1971; INBio, 1989; UAESPNN, 2005, Apéndice III; Rodríguez-Sevilla *et al.*, 2009; Finet *et al.*, 2011).

Subclass Heterobranchia Gray, 1840
Order Nudibranchia Cuvier, 1817
Superfamily Aeolidioidea Gray, 1827

Aeolidioidea indet. (Fig. 39, Code 80)

Material studied: Bahía Chatham: st. 4, d. 2, 34.8 m, 1 ind.

Size: 3.0 × 1.6 mm.

Remarks: With this specimen it was not possible to identify the species. But is a sea slug of the superfamily Aeolidioidea. The body of this slug is long and thin, with the foot slightly wider than the body. The lamellate rhinophores show brown pigment on the inner side, and a row of cerata at each side of the body.

Distribution: Mulliner (1993) reported the presence of an unidentified Aeolid nudibranch collected in 1992 in the PNIC. The species reported in Camacho-García (2009) from the sandy bottom of the island is *Aeolidiella indica* Bergh, 1888.

Superfamily Onchidoridoidea Gray, 1827
Family Onchidorididae Gray, 1827
Genus *Onchidoris* Blainville, 1816

Onchidoris sp. (Fig. 40, Code 81)

Material studied: Bahía Wafer: st. 19, d. 3, 23.6 m, 1 ind.

Size: 1.0 × 0.5 mm.

Remarks: The specimen is a small juvenile stage, showing a pair of ocelli. The shape is oval and flattened. The rhinophore is laminated. The mantle edge extends beyond the body, and present several spicules in an overlapping pattern, in the edge. This pattern characterizes this group as indicated by Debelius and Kuiter (2007) for the family Onchidorididae. This nudibranch was found in a small rhodolith, on the sand bottom.

Distribution: Mulliner (1993) and Camacho-García (2009) mentioned that there are five species of the family Dendrodorididae and Chromodorididae reported in the PNIC. New record of the genus from Isla del Coco.

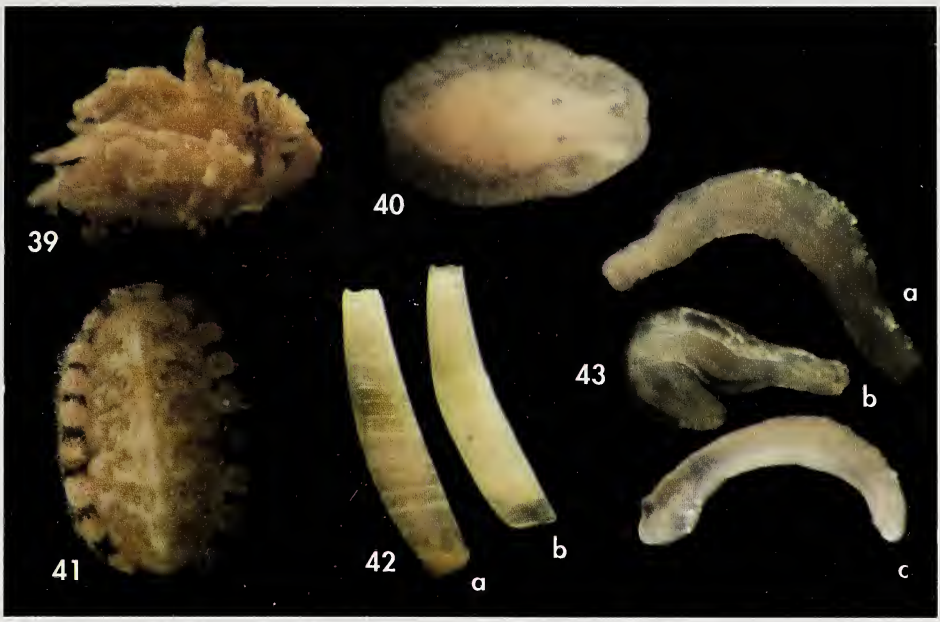

Figure 39. Aeolidioidea indet., 3.0 × 1.6 mm, st. 4. Figure 40. *Onchidoris* sp., 1.0 × 0.5 mm, st. 19. Figure 41. *Acanthochitona shaskyi* Ferreira, 1987, 3.5 × 2.2 mm, st. 1. Figure 42. *Gadila austinclarki* (Emerson, 1951), 3.5 × 0.1 mm, st. 3. Figure 43. Solenogastres indet., 2.0 × 0.4 mm, st. 1 and 3. Isla del Coco. April 2010.

Figura 39. Aeolidioidea indet., 3,0 × 1,6 mm, est. 4. Figura 40. Onchidoris *sp., 1,0 × 0,5 mm, est. 19. Figura 41.* Acanthochitona shaskyi *Ferreira, 1987, 3,5 × 2,2 mm, est. 1. Figura 42.* Gadila austinclarki *(Emerson, 1951), 3,5 × 0,1 mm, est. 3. Figura 43. Solenogastres indet., 2,0 × 0,4 mm, est. 1 y 3. Isla del Coco. April 2010.*

Class POLYPLACOPHORA Gray, 1821
Subclass NEOLORICATA Bergenhayn, 1955
Order CHITONIDA Thiele, 1909
Family ACANTHOCHITONIDAE Pilsbry, 1893
Genus *Acanthochitona* Gray, 1821

Acanthochitona shaskyi Ferreira, 1987 (Fig. 41, Code 82)

Acanthochitona shaskyi Ferreira, 1987, *Bull. Southern Cal. Acad. Sci.*, 86: 41-53.

Material studied: El Arco: st. 1, d. 1, 58 m, 2 ind.

Size: 2.2 × 1.2 – 3.5 × 2.2 mm.

Remarks: The individuals collected in the present study (found on rubble within the sand bottom) are similar to figure 126 in SLIEKER (2000) of *Acanthochitna angelica* Dall, 1919. The individual in SLIEKER (2000) was collected in Bahía Chatham, Isla del Coco, from 20-120 m, and the author mentioned that it is a paratype of *Acanthochitona shaskyi* Ferreira, 1987. *Acanthochitona angelica* was described from Angeles Bay, Gulf of California. FINET *ET AL.* (2011) mentioned that *A. angelica* was reported in Galapagos, with specimens from this archipelago originally classified as

Acanthochitona jacquelinae Smith and Ferreira, 1977. WATTERS (1990) synonymized both species with *A. angelica*, but EERNISSE (1993), studied the chitons of Donald R. Shasky and he maintained the species *A. shaskyi* as valid.

Distribution: EERNISSE (1993) mentioned that the distribution of *A. angelica* has more northern type localities in Mexico. Therefore, the report of *A. angelica* for PNIC (SCHWABE AND WEHRTMANN, 2009) corresponds to *A. shaskyi*. *Acanthochitona angelica* has never been collected on the Costa Rica mainland (INBIO, 1989; SCHWABE AND WEHRTMANN, 2009). A genetic study is required for these species.

Class SCAPHOPODA Bronn, 1862
Order GADILIDA Starobogatov, 1974
Family GADILIDAE Steiner, 1992
Genus *Gadila* Gray, 1847

Gadila austinclarki (Emerson, 1951) (Fig. 42, Code 83)

Cadulus austinclarki Emerson, 1951, J. Wash. Acad. Sci., 41: 24-26.
Gadila austinclarki (Emerson, 1951) – Steiner and Kabat, 2004, *Zoosystema*, 26: 566.

Material studied: Bahía Chatham: st. 3, d. 5, 75.3 m, 2 ind.

Size: 3.5 × 0.1 mm.

Remarks: The two individuals found show apex with four broad, shallow notches and are concordant in shape outline with figure 20 of the Scaphopoda chapter in KEEN (1971) of *Cadulus* (*Platyschides*) *austinclarki* Emerson, 1951. The size of the specimens also matches. They present somewhat ringed sculpture. STEINER AND KABAT (2004) placed *C. austinclarki* in the genus *Gadila*.

Distribution: Gulf of California to Panama, and Gálapagos (KEEN, 1971; FINET ET AL., 2011). Only one identified species of genus *Gadila* was reported for Costa Rica: *Gadila dominguensis* (d'Orbigny, 1853), but along the Caribbean coast (INBIO, 1989). Other indeterminate specimens of Gadilidae were also reported by INBIO (1989) for the Pacific coast of Costa Rica. The species is a new record for Isla del Coco and Costa Rica.

MONTOYA (1988) mentioned the presence of one Scaphoda species in PNIC. Montoya, Shasky & Kaiser (unpublished manuscript, 1988) mention the presence of the Scaphopoda *Cadulus* (*Polyschides*) *nedallisoni* Emerson, 1978 (Siphonodentaliidae), now accepted as *Polyschides nedallisoni* (Emerson, 1978) (Gadilidae) in STEINER AND KABAT (2004). It was collected with a triangular dredge at 45 and 70 m outside Bahía Chatham. In this way, *G. austinclarki* is the second identified species of the class Scaphopoda from the island.

Class SOLENOGASTRES Gegenbaur, 1878

Solenogastres indet. (Fig. 43 a-c, Code 84)

Material studied: El Arco: st. 1, d. 4, 60.6 m, 1 ind. Bahía Chatham: st. 3, d. 5, 75.3 m, 2 ind.

Size: 2.0 × 0.4 mm.

Remarks: These vermiform organisms do not have a shell, and the body is covered with calcareous elements or sclerites. The foot is apparently reduced to a ventral groove. The specimens present an atrio-buccal area, and are without gills (GARCÍA-ÁLVAREZ AND URGORRI, 2003).

Distribution: This is a new record of these Mollusks for Central American waters.

DISCUSSION

In the present study 40 species of mollusks were found in the subtidal sand bottom of Isla del Coco. Eleven taxa are new records for the National Park; five were identified to the species level: *Ctena mexicana* (Dall 1901), *Parvilucina mazatlanica* (Carpenter, 1857), *Diarmaidia jingchunae* Valentich-Scott, in Coan and Valentich-Scott, 2012, *Gibberula* cf. *insularum* (Roth and Coan, 1971), *Gadila austinclarki* (Emerson, 1951); and *Caecum cocoensis* sp. nov. was described. Two species of nudibranchs were found but could not be identified. Specimens of Solenogastres are a new record of the class for Central American waters.

The *Diplodonta* sp. found is a possibly new species, and similar situation occurs with *Opalia* (*Dentiscala*) sp. and *Tellina* (*Morella*) sp. More sampling is needed to obtain additional specimens of these genera. CORTÉS (2012) and COAN AND VALENTICH-SCOTT (2012), first reported the species *Diplodonta subquadrata* Carpenter, 1856 for the PNIC; but the specimens found in the present study are juvenile stages of this genus. Other mollusks such as *Gouldia californica* Dall, 1917, *Plaktomya* cf. *henseni* Simroth, 1896, and *Trigonulina novemcostata* (A. Adams and Reeve, 1850), are the second report of these species in Isla del Coco, after the recently published catalogue of bivalves of the Eastern Tropical Pacific by COAN AND VALENTICH-SCOTT (2012).

The number of species in the National Park increased with each expedition carried out (CORTÉS, 2008), in this way, BIOLLEY (1935) reported only 23 marine mollusks, MONTOYA (1983) and MONTOYA AND BARTSCH (1983) indicated a number of 118 species, and in a posterior publication MONTOYA (1988) indicates 429 species of mollusks in PNIC. Most of the records are the product of the malacological expeditions carried out between 1982 and 1989 on board the schooner *Victoria af Carlstad* with the participation of Donald R. Shasky, Kirstie L. Kaiser and Michel Montoya (CORTÉS, 2008). The number of marine mollusks in the book of WEHRTMANN AND CORTÉS (2009) is 428 species, based on the lists by CAMACHO-GARCÍA (2009), HOCHBERG AND CAMACHO-GARCÍA (2009), MAGAÑA-CUBILLO AND ESPINOSA (2009), RODRÍGUEZ-SEVILLA *ET AL.* (2009), SCHWABE AND WEHRTMANN (2009). The total number reported in the review of biodiversity of the island by CORTÉS (2012) still increased to 490 species.

MULLINER (1993) and KAISER (2007) report several species of marine gastropods for the Isla del Coco, not mentioned in the previous species list: *Atlanta turriculata* d'Orbigny, 1836, *Attiliosa nodulosa* (A. Adams, 1855), *Cavolinia* cf. *tridentata* (Niebuhr, 1775), *Cavolinia uncinata* (Rang, 1829), *Creseis* cf. *acicula* (Rang, 1828), *Limacina bulimoides* (Orbigny, 1836), *Dolabella auricularia* (Lightfoot, 1786), *Dolabrifera dolabrifera* (Rang, 1828), *Elysia diomedea* (Bergh, 1894), *Janthina janthina* (Linnaeus, 1758), *Nassarius catallus* (Dall, 1908), *Oxygyrus keraudrenii* (Lesueur, 1817), *Pachystremiscus solitarius* (Hertlein and Allison, 1968), *Quoyula monodonta* (Blainville, 1832), *Scissurella kaiserae* Geiger, 2006, and *Tylodina fungina* Gabb, 1865. In addition KAISER (2007), presented plates with figures of several gastropods identified to genus or subfamily level found on Clipperton Island, that she mentinoned also to occur in Isla del Coco: *Cerithium* sp. 2 (Plate 17, Fig. 1c,d), Coralliophilinae sp. 1. (Plate 31, Fig. 6, 7), *Elachisina* sp. 1 (Plate 14, Fig. 5), *Graphis* sp. 1 (Plate 18, Fig. 6), *Omalogyra* sp. 1 (Plate 36, Fig. 7), *Orbitestella* sp. 1 (Plate 39, Fig. 4), *Sinezona* sp. 1 (Plate 9, Fig. 1).

COAN AND VALENTICH-SCOTT (2012) made direct reference to 64 species of bivalves from Isla del Coco, and 20 of them are additional record to the list of CORTÉS (2012): *Amerycina mikkelsenae* Valentich-Scott, 2012, *Apiocardia obovale* (G.B. Sowerby I, 1833), *Cardita aviculina* Lamarck, 1819, *Cardites grayi* (Dall, 1903), *Caryocorbula ira* (Dall, 1908), *Chama echinata* Broderip, 1835, *Ctena chiquita* (Dall, 1901), *Gastrochaena ovata* G.B. Sowerby I, 1834, *Gouldia californica* Dall, 1917, *Hyotissa hyotis* (Linnaeus, 1758),

Hyotissa quercinus (G.B. Sowerby II, 1871), *Limopsis tenella* Jeffreys, 1876, *Liralucina approximata* (Dall, 1901), *Pitar* (*Hyphantosoma*) *pollicaris* (Carpenter, 1864), *Planktomya* cf. *henseni* Simroth, 1896, *Plectodon scaber* Carpenter, 1865, *Spondylus gloriosus* Dall, Bartsch and Rehder, 1938, *Trigoniocardia granifera* (Broderip and G.B. Sowerby I, 1829), *Trigonulina novemcostata* (A. Adams and Reeve, 1850) and *Tucetona multicostata* (G.B. Sowerby I, 1833). Including the scaphopod *Polyschides nedallisoni* (Emerson, 1978) by Montoya, Shasky and Kaiser (unpublished manuscript, 1988), not mentioned in the others lists, brings the number to 534 species. Adding the eleven new records found in the present study, a grand total of 545 species of mollusks are present in Isla del Coco.

From this new total of species in PNIC, the percent of gastropods are 75% and bivalves only 19%. Morevoer, only 180 (33%) inhabit in marine sediments (Kaiser, 2007; Wehrtmann and Cortés, 2009; Coan and Valentich-Scott, 2012). Considering separately the sediments habitat of the PNIC, the contribution of gastropods is 57.8%, bivalves 38.3%, and other mollusks 3.9%. Therefore, the bivalves have a greater richness in soft bottom (69 species) than in the hard substrates (37 species) (Wehrtmann and Cortés, 2009). These percentajes are similar with the contribution found for soft bottoms in present study, with 52.5% of gasteropods, 40% of bivalves, and 7.5% by other groups.

As is mentioned above, in PNIC the general data indicate an 75% of gastropods and 19% of bivalves (Fig. 44), while in the pacific coast of Costa Rica, the contribution of species of gastropods and bivalves, averaged between 64 and 67% and 30 to 34%, respectively, depending of the reference (INBio, 1989; Werthmann and Cortés, 2009). In other places of the pacific coast the percentage of bivalves is higher than 25%, in Gorgona (a continental island) the bivalves are 29% and the gastropods 69%, and Tres Marías, Mexico (26% bivalves and 73% gastropods). Even so, the percentages of total species in Isla del Coco (19% bivalves and 75% gastropod) are similar with the other oceanic islands of the region (Fig. 44) as Malpelo (18% bivalves and 79% gastropod), Galapagos (24% bivalves and 72% gastropod), Clipperton (13% bivalves, 86% gastropod) and Revillagigedo (14% bivalves, 83% gastropod) (Strong and Hanna, 1930a; Strong and Hanna, 1930b; UAESPNN, 2005, Apéndice III; Kaiser, 2007; Finet et al. 2011). The gastropod group dominates, and the bivalves have a lesser percentage of representation in these oceanic islands than in mainland.

Despite the low number of 40 species found, the methodological survey used here is adequate to preserve the whole community of sand substrate, and the use of mesh sieves helped to retain the small specimens of several species, that resulted be new records for the island. The species distribution also changes with depth, so that possibly sampling at a greater depth of the sand bottom will increase the number of species for this habitat of the PNIC. In sedimentary habitats (sampled with grabs) of mainland of Central America, Maurer and Vargas (1984) only found 22 species of mollusks in Golfo de Nicoya (Costa Rica), Mair, Cunningham, Sibaja-Cordero, Guzmán, Arroyo, Merino, and Vargas (2009) found 33 taxa in the islands Las Perlas, Panamá.

In the oceanic islands of the Tropical Eastern Pacific the presence of marine mollusks from different biogeographic provinces, including species with Indo-Pacific affinities is documented (Shasky, 1987; Shasky, 1988; Scheltema, 1988; Finet, 1991; Kaiser, 2007). This situation is accentuated in Isla del Coco, by its geographic position at 5°N in the middle of the intertropical convergence zone, which in April is influenced by South and Central American currents and in October by the Equatorial Counter Current (Fig. 1), especially during El Niño year. This current would carry larvae to the island from different regions of the Tropical Pacific to the island (Shasky, 1987; Montoya, 1988). Montoya (1988) indicated that the

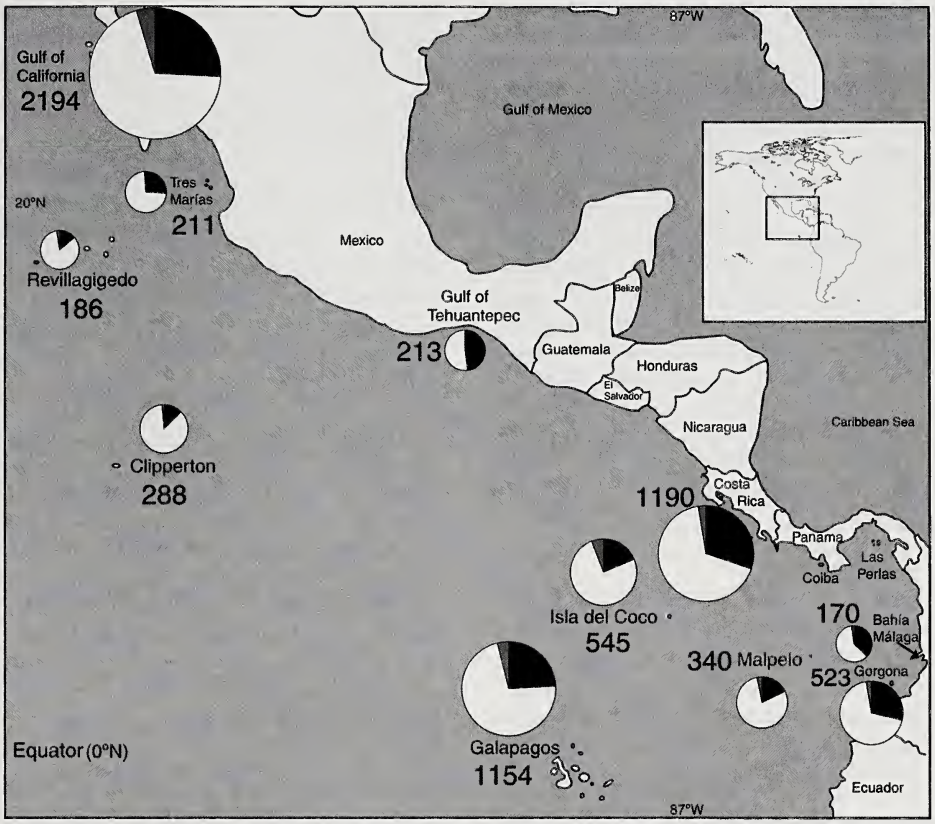

Figure 44. Number of marine mollusks species, and the percentual contribution of bivalves (black), gastropod (white) and other mollusks (gray) to species richness, by locality in the Eastern Tropical Pacific Ocean. Based on the references for Gulf of California, Mexico: Hendrickx, Brusca, Cordero and Ramírez, 2007. Islas Tres Marías, Mexico: STRONG AND HANNA, 1930b; Islas Revillagigedo, Mexico: STRONG AND HANNA, 1930a; MILLE-PAGAZA, PÉREZ-CHI AND HOLGUÍN-QUIÑONES, 1994; KAISER, 2007. Gulf of Tehuantepec, Mexico: RÍOS-JARA, NAVARRO-CARAVANTES, GALVÁN-VILLA AND LOPEZ-URIARTE, 2009. Isla Clipperton, Frensh possession: KAISER, 2007. Pacific Coast of Costa Rica: WEHRTMANN AND CORTÉS, 2009. Isla del Coco, Costa Rica: MULLINER 1993; KAISER, 2007; CORTÉS, 2012 and present study. Islas Malpelo and Gorgona, Colombia: UAESPNN, 2005, Apéndice III. Bahía Malaga, Colombia: GUEVARA-FLETCHER, CANTERA-KINTZ, MEJÍA-LADINO AND CORTÉS, 2011; LOZANO-CORTÉS, LONDOÑO-CRUZ, IZQUIERDO, ARIAS, BARONA AND ZAMBRANO, 2012. Islas Galapagos, Ecuador: FINET *ET AL.*, 2011.

Figura 44. Número de especies de moluscos marinos y la contribución porcentual de los bivalvos (negro), gasterópodos (blanco) y otros moluscos (gris) a la riqueza de especies, por localidad en el Océano Pacifico Tropical Este. Basado en las referencias para el Golfo de California, México: HENDRICKX, BRUSCA, CORDERO Y RAMÍREZ, 2007. Islas Tres Marías, México: STRONG Y HANNA, 1930b. Islas Revillagigedo, México: STRONG Y HANNA, 1930a; MILLE-PAGAZA, PÉREZ-CHI Y HOLGUÍN-QUIÑONES, 1994; KAISER, 2007. Golfo de Tehuantepec, México: RÍOS-JARA, NAVARRO-CARAVANTES, GALVÁN-VILLA Y LOPEZ-URIARTE, 2009. Isla Clipperton, posesión francesa: KAISER, 2007. Costa Pacífica de Costa Rica: WEHRTMANN Y CORTÉS, 2009. Isla del Coco, Costa Rica: MULLINER 1993; KAISER, 2007; CORTÉS, 2012 y el estudio presente. Islas Malpelo y Gorgona, Colombia: UAESPNN, 2005, Apéndice III. Bahía Málaga, Colombia: GUEVARA-FLETCHER, CANTERA-KINTZ, MEJÍA-LADINO Y CORTÉS, 2011; LOZANO-CORTÉS, LONDOÑO-CRUZ, IZQUIERDO, ARIAS, BARONA Y ZAMBRANO, 2012. Islas Galápagos, Ecuador: FINET ET AL., *2011.*

molluscan assemblage of the island consisted of ~88% Panamic, 7.5% Indo-Pacific, and 2.3% cosmopolitan species.

Moreover, five of the species found here are also present in Revillagegido Islands (Mexico), four species also occurs in Clipperton (French colony); six species are present in Malpelo (Colombia); and 21 species are present also in Galapagos Islands (Ecuador). Several of the species also occurs in the Pacific Coast of Central America. The species *Oxymeris maculata* (Linnaeus, 1758) and *Mammilla simiae* (Deshayes, 1838), have a wide distribution in the Indo Central Pacific, and the gastropod *Gibberula* cf. *insularum* (Roth and Coan, 1971), was cited previously only for the Galapagos.

CONCLUSIONS

In the present study only 40 molluscan taxa were found in the sand bottom of Isla del Coco, among which eleven taxa are new records for this National Park, or represent new records for Costa Rica and Central American waters. In addition, the malacofauna in the sandy bottom of these samples is a mix of species with distribution from different biogeographic provinces. The *Caecum* specimens found represent a new species.

The low number of species found could be explained by the tendency of species diversity to change with depth, and that the sampling was carried out within a narrow bathymetric range between 3 to 75 m. This finding indicates that with more sampling, at greater depth, the number of species present will increase. The total number of species reported in the region has been increased to 545, including the results of the present study and literature of the Tropical Eastern Pacific. The percent of bivalves is low in the island, because most of the habitats are hard substrates, like in the others islands of the region, but the information presented here suggests that the sand bottom of PNIC is rich in bivalves species, and that more sampling is needed.

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Une nouvelle espèce de la famille Aglajidae (Gastropoda: Opisthobranchia) des côtes de Méditerranée française

Una nueva especie de la familia Aglajidae (Gastropoda: Opisthobranchia) de la costa francesa del Mediterráneo

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RÉSUMÉ

Une nouvelle espèce du genre *Philinopsis* est décrite de Méditerranée française, et comparée aux autres espèces d'Aglajidae connues dans le domaine européen.

RESUMEN

Se describe una nueva especie del genero *Philinopsis* de la costa mediterránea francesa y se compara con otras especies de Aglajidae conocidas del área europea.

ABSTRACT

A new species of the genus *Philinopsis* is described from the French Mediterranean coast and compared with other species of Aglajidae known from the European area.

INTRODUCTION

Depuis quelques années une espèce de petite limace de mer est régulièrement trouvée sur le littoral français, depuis Banyuls jusqu'à Saint Raphaël, à faible profondeur sur fonds durs ainsi qu'un peu partout en Méditerranée occidentale. Cette limace caractéristique a été photographiée à de nombreuses reprises, et des photographies se trouvent postées sur divers forums internet consacrés aux limaces de mer.

L'identification de cette espèce étant incertaine, les auteurs ont décidé de l'étudier. La forme de l'animal vivant et surtout les parapodies collées au corps ainsi que la forme de la coquille interne ont montré clairement qu'elle appartenait à la famille des *Aglajidae* (Rudman, 1974; Gosliner, 1980; Ortea, Espinosa, Moro, Caballer & Bacallado, 2012)

MATÉRIEL ET MÉTHODE

Le matériel étudié a été récolté en plongée sous-marine sur des fonds de sable et roches recouvertes d'algues courtes brunes et vertes, de la région de La Ciotat (Bouches du Rhône, France) à faible profondeur (2 à 7 m). Cette espèce est retrouvée depuis plusieurs années entre mars et décembre. L'holotype et les paratypes 1 et 3 ont été conservés dans l'alcool, les paratypes 2, 4 et 9 ont été disséqués pour extraire la coquille interne.

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Cinq spécimens conservé en alcool ont été communiqués à Ángel Valdés (California State Polytechnic University) pour être inclus dans une série d'analyses moléculaires portant sur l'ensemble de la famille.

L'information disponible sur les sites Internet présentant des photographies de cette espèce a été actualisée, les sites indiqués étant actifs à la date du 12 juillet 2013.

SYSTEMATIQUE

Famille Aglajidae Pislbry, 1895
Genre *Philinopsis* Pease, 1860

Espèce type par désignation subséquente (Rudman, 1972a: 389): *Philinopsis speciosa* Pease, 1860.

Philinopsis miqueli spec. nov. (Figs. 1-6)

Matériel type: Holotype (12 x 3,5 mm, récolté le 23.03.2013), Muséum National d'Histoire Naturelle, Paris, n° 25768 (Figs 1a-1b); paratypes 1 et 2 (11 x 3,5 mm et 10 x 3,5 mm, récoltés le 17.03.2013), Muséum National d'Histoire Naturelle, Paris; paratypes 3 et 4 (10 x 3,5 mm et 11 x 3,5 mm, récoltés le 23.03.2013, collection Jacques Pelorce; paratypes 5 et 6 (10,5 x 3,5 mm, récoltés le 23.03.2013, collection André Hoarau; paratypes 7 et 8 (11 x 3,5 mm, récoltés le 23.03.2013), collection Jean-Pierre Miquel; tous de la localité type. Paratype 9, La Ciotat (Bouches du Rhône), Calanque de Figuerolles, -5 m, fond de sable, roches et algues courtes, 24.08.2012, Muséum National d'Histoire Naturelle, Paris (Figure 2).
Autre matériel examiné: La Ciotat (Bouches du Rhône), Calanque du Mugel, -4 m, fond de sable et roches avec algues courtes, réc. Jean-Pierre Miquel, 31.03.2012. La Ciotat (Bouches du Rhône), Calanque du Mugel, -2,5 m, fond de sable et cailloux recouvert d'algues, rec. Jean-Pierre Miquel 24.04.2013, 5 spécimens envoyés à Ángel Valdés pour étude moléculaire. St Raphaël (Var), Calanque de St Barthélemy, -4 m, fond de cailloutis, photo de Dominique Horst, 03.06.2012 (non récolté). St Raphaël (Var), "Les Vieilles", - 4 m, fond de cailloutis, photo de Dominique Horst, 07.07.2012 (non récolté).
Photographies de diverses localités de la Méditerranée occidentale postées sur Internet: sous le nom de *Philine aperta* (Linnaeus, 1767): http://www.cibsub.com/bioespecie.php?idg=27918 (photo Jordi Regás, localité et date non précisés); http://www.natuurlijkmooi.net /adriatische_zee/naaktslakken/philine_aperta.htm (photo Anne Frijsinger & Mat Vestjens, Selce, Croatie, 2008); http://entitu.blogspot.com.es/2009/03/philine-aperta.html (photographe non précisé, Aiguafreda, Begur, 4 m, mars 2009, et Tossa de Mar, la Mar Menuda, 7 m, septembre 2011 ; province de Gerona, Espagne); http://www.flickr.com/photos/30110344@N07/4398375589/ (photo Fernando Darder Garau, Puerto Cocodrilo, Mal Pas, Bahía de Pollensa, Alcudia, Majorque); http://www.forobuceo.com/phpBB3/viewtopic.php?f=5&t=45818 (photo Josep Ciurana, entre Barcelone et Tossa de Mar, juillet 2008); http://www.flickr.com /photos/josep_lluis_peralta/7302911672/ (photo Josep Lluis, Cadaques, Es Caials, province de Gerona, Espagne, mai 2012; http://opistobranquis.info/en/guia-dopistobraquis/cefalaspideus-cephalaspidea/ (photo Enric Madrenas, localité et date non précisés); sous le nom de *Philine quadripartita* Ascanius, 1772: http://www.medslugs.de/E/Med/Philine_quadripartita_11.htm; Cagliari, Sardaigne, photo Alberto Piras, Cagliari, Sardaigne, Juillet 1984); sous le nom de *Melanochlamys algirae* (Adams, 1850): http://www.naturamalta.com/Melanochlamys_algirae.html (photos Carmel Sammut, Ghar Lapsi, Malte, 2 m, mai 1992 et Zonqor Point, Malte, 17-18 m, janvier 1996).
Etymologie: L'espèce est nommée en honneur de Jean-Pierre Miquel, plongeur, photographe sous-marin et collectionneur passionné, qui nous a fourni le matériel type et a procédé à l'extraction de la coquille interne.
Localité type: Calanque du Mugel, Golfe de La Ciotat, département des Bouches du Rhône, côte française de Méditerranée, entre 2 et 5 mètres de profondeur sur fonds durs.

Description: L'animal en extension a un corps oblong allongé, environ 13 mm de long pour 4 mm de large (Figures 1, 3-5). Le bouclier céphalique occupe légèrement plus de la moitié de la longueur du dos, et sa partie postérieure est arrondie

sur les bords et rectiligne au milieu. Un léger sillon est visible au milieu du bouclier céphalique et une très légère échancrure est présente sur sa partie antérieure. La partie postérieure du dos forme aussi un bouclier qui renferme la coquille réduite. Le bord postérieur est légèrement ondulé et ne présente pas de flagellum. Le pied est presque aussi long que le corps, avec des parapodies épaisses, peu étendues et collées au corps. La coloration, constante, est constituée de centaines de petits points blancs disposés à la surface, sur un fond translucide qui donne à l'animal une couleur qui semble être blanche uniforme. Une ligne blanche plus intense souligne le bord des parapodies et les bordures postérieures des boucliers céphalique et postérieur.

La coquille (Figure 2) est interne, calcifiée, très mince, fragile, blanche translucide, enroulée sur elle-même, allongée et décrivant un tour et demi. Le nucleus présente une excroissance en forme de coupelle, des stries d'accroissement sont visibles à l'intérieur et à l'extérieur, pas de stries longitudinales, la bordure externe est épaissie.

La partie antérieure de l'appareil digestif comprend un bulbe buccal extrêmement volumineux (Figure 6A). Postérieurement à celui-ci sont insérées de petites glandes salivaires; un court oesophage communique le bulbe buccal avec un gésier qui est dépourvu de plaques calcifiées.

La partie mâle de l'appareil reproducteur comporte un pénis allongé et dilaté dans sa partie distale (Figure 6B), en prolongation d'une glande de la prostate allongée et contournée sur elle même.

Habitat: Le biotope de la nouvelle espèce est constitué de petites algues, brunes et vertes, et poches de sable sur fonds durs entre 2 et 5 m de profondeur.

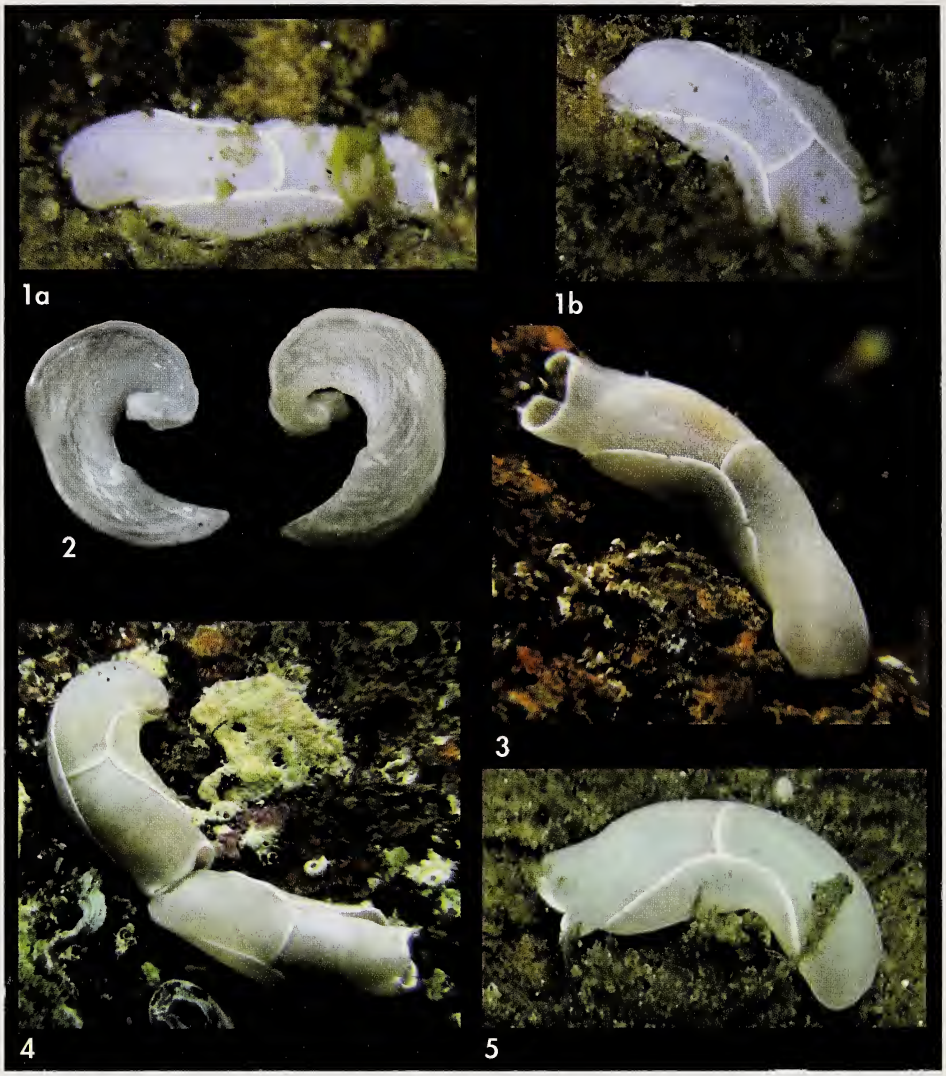
Comportement: Nous avons remarqué certains individus formant une chaîne (Figure 4) dans laquelle un individu insère la partie antérieure du corps à l'arrière des parapodies de celui qui le précède. Ce comportement est connu chez les Aglajidae (KRUG, MORLEY, ASIF, HELLYAR & BLOM, 2008) et se trouve lié à la copulation.

Distribution: Connue de toute la Méditerranée occidentale depuis les côtes espagnoles (Almuñecar, province de Grenade: TEMPLADO, 2011) jusqu'à Malte (site Internet < http://www.naturamalta.com/>) et dans l'Adriatique (site Internet <http://www.natuurlijkmooi.net/>.

Discussion: L'attribution générique de la nouvelle espèce n'est pas déterminable par les seuls caractères externes ni par ceux de la coquille, qui pourraient correspondre aux genres *Philinopsis* Pease, 1860 ou *Melanochlamys* Cheeseman, 1881. Nous l'incluons ici dans le genre *Philinopsis* au vu de résultats préliminaires d'analyse moléculaire par lequels la nouvelle espèce est regroupée avec *Philinopsis speciosa* et avec *Philinopsis depicta*, plutôt qu'avec les espèces de *Melanochlamys* incluses dans l'analyse (A. Valdés, communication personnelle, 07/2013). La structure de l'énorme bulbe buccal est habituelle dans la famille (RUDMAN, 1972b), sans être diagnostique du genre.

En Méditerranée, une seule espèce est actuellement reconnue dans le genre, *Philinopsis depicta* (Renier, 1807), facilement distinguée de notre nouvelle espèce par sa couleur très variable et vive, son bouclier céphalique relevé vers l'arrière, sa taille beaucoup plus grande, jusqu'à 10 cm et son habitat sur des fonds sablo-vaseux.

La nouvelle espèce a été régulièrement confondue (par exemple, TEMPLADO, 2011, et les photographies citées dans le matériel examiné) avec *Philine quadripartita* Ascanius, 1772 qui s'en distingue aisément par sa taille beaucoup plus grande, la forme de la tête plus triangulaire, les parapodies non collées au corps, la présence de plaques gastriques très importantes, et la coquille calcifiée enroulée. Cette *Philine* était généralement connue dans la littérature européenne sous le nom de *P. aperta* (Linnaeus, 1767) jusqu'à ce que PRICE, GOSLINER & VALDÉS (2011) démontrent que le nom valide pour l'espèce européenne est *Philine quadripartita* et que la véritable *Philine aperta* est une espèce d'Afrique du Sud. Cette *Philine* se distingue aussi par son habitat sur des fonds sablo-vaseux plus profonds.



Figures 1-5. *Philinopsis miqueli* spec. nov. 1a, b: holotype 12 mm x 3,5mm, La Ciotat (Bouches du Rhône), Calanque du Mugel, -2,5 m, fond de sable et roches avec algues courtes, photo Jean-Pierre Miquel 24/03/2013; 2: coquille du paratype 9, La Ciotat (Bouches du Rhône), Calanque de Figuerolles, -5 m, fond de sable, roches et algues courtes, 24/08/2012 (3,0 x 2,2 mm); 3: spécimen de St Raphaël (Var), Calanque de St Barthélemy, -4 m, fond de cailloutis, photo Dominique Horst 03/06/2012; 4: spécimens de St Raphaël (Var), "Les Vieilles", -4 m, fond de cailloutis, photo Dominique Horst 07/07/2012; 5: La Ciotat (Bouches du Rhône), Calanque du Mugel, -4 m, fond de sable et roches avec algues courtes, photo Jean-Pierre Miquel 31/03/2012.

Figuras 1-5. Philinopsis miqueli *spec. nov. 1a, b: holotipo 12 mm x 3,5mm, La Ciotat (Bouches du Rhône), Calanque du Mugel, -2,5 m, fondo de arena y roca con algas cortas, fotografía Jean-Pierre Miquel 24/03/2013; 2: concha del paratipo 9, La Ciotat (Bouches du Rhône), Calanque de Figuerolles, -5 m, fondo de arena, rocas y algas cortas, 24/08/2012 (3,0 x 2,2 mm); 3: especimen de St Raphaël (Var), Calanque de St Barthélemy, -4 m, fondo de grava, fotografía Dominique Horst 03/06/2012; 4: especimenes de St Raphaël (Var), "Les Vieilles", -4 m, fondo de grava, fotografía Dominique Horst 07/07/2012; 5: La Ciotat (Bouches du Rhône), Calanque du Mugel, -4 m, fondo de arena y rocas con algas cortas, fotografía Jean-Pierre Miquel 31/03/2012.*

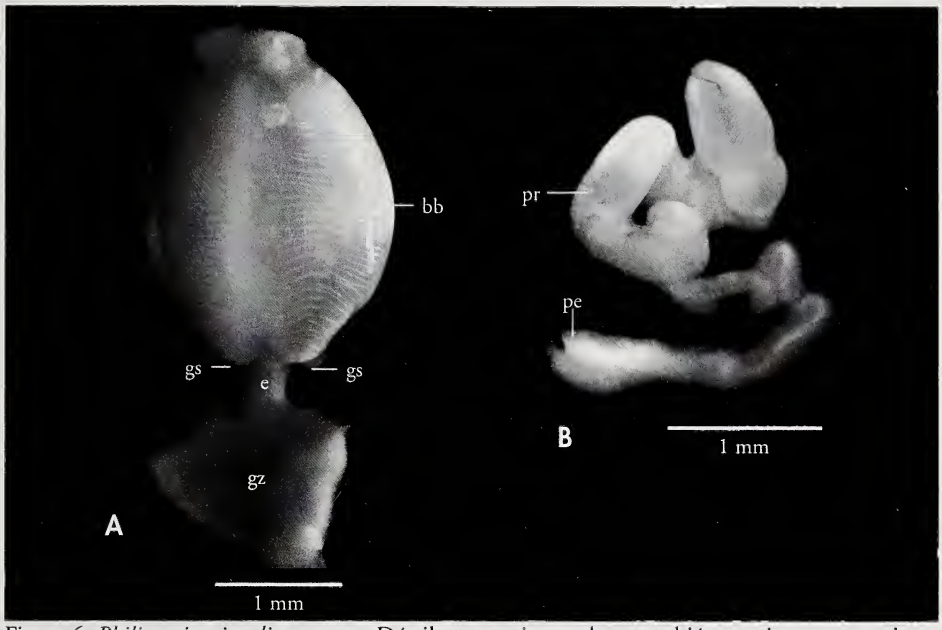


Figure 6. *Philinopsis miqueli* spec. nov. Détails anatomiques photographiés au microscope optique, spécimen de La Ciotat (Bouches du Rhône), Calanque du Mugel, -2,5 m, 24/03/2013. A. Bulbe buccal et gésier; bb: bulbe buccal; gs: glandes salivaires; e: oesophage; gz: gésier. B: Pénis; pr: grande prostatique; pe: papille péniale. Photo: Ángel Valdés.

Figure 6. Philinopsis miqueli *spec. nov. Detalles anatómicos al microscopio óptico, especimen de La Ciotat (Bouches du Rhône), Calanque du Mugel, -2,5 m, 24/03/2013. A. Bulbo bucal y molleja; bb: bulbo bucal; gs: glándulas salivares; e: esófago; gz: molleja. B: Pene; pr: glándula prostática; pe: papila peneal. Fotografía: Ángel Valdés.*

Dans le domaine européen, plusieurs autres espèces d'Aglajidae ont été placées dans le genre *Melanochlamys*. Notre espèce ressemble superficiellement à *Melanochlamys seurati* (Vayssière, 1926), décrite du Golfe de Gabès (Tunisie) mais le bord du manteau ne présente pas l'échancrure postérieure qui apparaît clairement sur la figure de VAYSSIÈRE (1926). L'animal de *M. seurati* est décrit comme blanchâtre mais aucune mention d'est faite du liséré bien marqué qui caractérise *Philinopsis miqueli* spec. nov. La coquille de *Melanochlamys seurati* est très différente, avec une surface qui s'élargit considérablement au long du dernier tour, et un labre d'une hauteur égalant plus ou moins le diamètre de la coquille (VAYSSIÈRE, 1926, figure 3-4; MICALI & SCUDERI, 2006, figure 1) et formant avec le bord columellaire un angle inférieur à 90°. La coquille de *Philinopsis miqueli* spec. nov. constitue en revanche une bande spiralée étroite, le labre formant un angle très obtus avec le bord columellaire. Dans le même article, MICALI & SCUDERI (2006) figurent sous le nom de *M. seurati* un autre spécimen qui montre des plaques gésiales bien développées et appartient donc au genre *Philine*. *Bulla algirae* A.Adams in G.B. Sowerby II, 1850 a été décrite à partir d'une coquille isolée et pourrait être un nom plus ancien pour *M. seurati*; assumant cette synonymie indiquée dans la base de données CLEMAM < http://www.somali.asso.fr/clemam/biotaxis.php?X=18952> c'est sous le nom de *Melanochlamys algirae* que notre espèce est citée sur le site Internet < http://www.naturamalta.com/>.

Melanochlamys maderensis (Watson, 1897) décrit de l'île de Madère est caractérisée par des taches blanches et pour-

pres sur le pied (Ortea & Moro, 1998) bien différentes de la coloration de notre espèce. *Melanochlamys wildpreti* Ortea, Bacallado & Moro, 2003, décrite des Iles Canaries, possède une coquille interne très différente, avec plusieurs projections pointues sur la partie apicale et une coloration externe de l'animal marron parsemée de points jaunes; elle a été placée en synonymie de *Spinoaglaja aeci* (Ortea & Espinosa, 2001) par Ortea, Moro & Espinosa (2007).

Il est étonnant que cette espèce apparemment commune n'aie pas été reconnue auparavant, mais cela s'explique probablement du fait des confusions habituelles avec les *Philine*, réputées être les seuls céphalaspides ayant cet aspect extérieur et une couleur blanche.

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Notas breves

Protocolo no letal para la obtención de muestras de tejido (para estudios genéticos) en la lapa amenazada *Patella ferruginea* (Gastropoda, Patellidae)

Non-lethal protocol for tissue-sampling (for genetic studies) in the endangered limpet *Patella ferruginea* (Gastropoda, Patellidae)

Javier GUALLART, Iván ACEVEDO, Marta CALVO y Annie MACHORDOM*

Recibido el 6-XI-2012. Aceptado el 15-IV-2013

La lapa ferruginosa (*Patella ferruginea*) es una de las especies de invertebrados más amenazadas del mar Mediterráneo, incluida en el Catálogo Español de Especies Amenazadas como "en peligro de extinción" (Templado, Calvo, Luque, Garvía, Maldonado y Moro, 2004). La Estrategia para la conservación de esta especie en España (MMAMRM, 2008) incluye, entre las directrices de conservación, la caracterización genética y el estudio del flujo genético entre las distintas poblaciones existentes en la actualidad.

Este tipo de trabajos reviste una gran importancia para la especie, no sólo como un conocimiento científico básico, sino como una herramienta para la toma de decisiones dirigidas a su conservación. Determinar el grado de conectividad o aislamiento genético entre las poblaciones de diferentes enclaves resulta fundamental para decidir el origen de los ejemplares utilizados ante una eventual repoblación o reintroducción de la especie. Por otra parte, tras llevar a cabo estas intervenciones, a medio plazo resultaría de gran interés evaluar la suficiencia reproductora de cada una de estas poblaciones o la existencia de un aporte o flujo de larvas de su entorno, aspectos que pueden evaluarse mediante técnicas moleculares. Afortunadamente, para la especie que nos ocupa, se cuenta con distintas técnicas para obtener estos parámetros genéticos que tanto pueden aportar en la toma de decisiones sobre su gestión o conservación. Se han desarrollado, por ejemplo, marcadores hipervariables analizando ISSR (por las siglas inglesas Inter Simple Sequence Repeats) (Casu, Rivera-Ingraham, Cossu, Lai, Sanna, Dedola, Sussarellu, Sella, Cristo, Curini-Galletti, García-Gómez y Espinosa, 2012) o microsatélites (Machordom, Ramírez-Escobar, Acevedo, García-Jiménez, Cabezas, Calvo, Toledo y Bloor, 2010).

La realización de este tipo de estudios genéticos en general requiere la obten-

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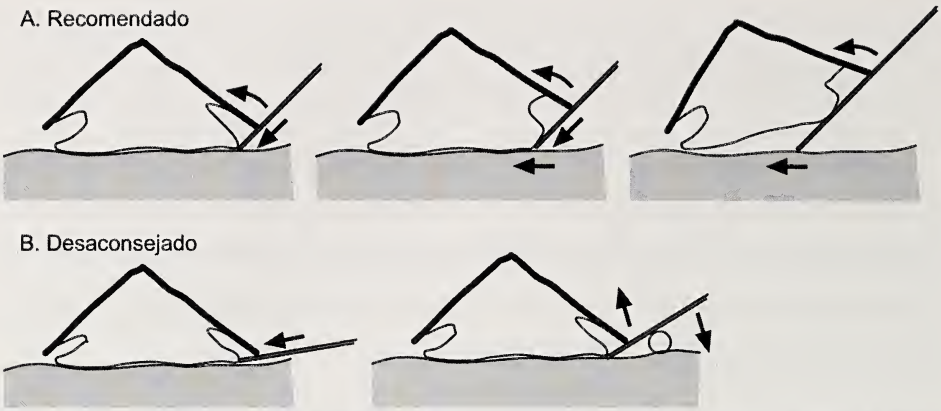

Figura 1. Procedimiento para la separación de ejemplares del sustrato usando un cuchillo de punta roma. A. Serie de movimientos recomendada. B. Procedimientos desaconsejados.
Figure 1. Specimens separation from the substrate using a blunt knife. A. Recommended movements. B. Discouraged procedure.

ción de una muestra de tejido en un elevado número de ejemplares de una serie de poblaciones (al menos una treintena). En otras especies de invertebrados generalmente la toma de muestras supone la captura y sacrificio de los ejemplares. Sin embargo, este planteamiento resulta totalmente desaconsejable en una especie gravemente amenazada.

Se plantea aquí un protocolo de trabajo que tiene como objetivo obtener muestras de tejido en *P. ferruginea* de volumen suficiente para realizar estudios genéticos, pero sin el sacrificio de los ejemplares y que minimice todo lo posible la mortalidad de los mismos después de realizada la extracción. Esta metodología que se propone se ha ensayado en las islas Chafarinas, donde se localiza una población natural de la especie que, por su abundancia y renovación regular mediante el reclutamiento anual, posibilitan llevar a cabo este tipo de experiencias.

El protocolo de trabajo que se plantea incide en dos aspectos: 1) el método para la captura y devolución de los ejemplares al medio natural y 2) la parte del animal donde realizar la extracción de tejido. Este protocolo puede resumirse en los siguientes puntos:

1. La captura de los ejemplares debe realizarse siempre cuando éstos están desplazándose fuera de su "huella" (*home-scar*). Esto tiene lugar preferentemente con marea alta y cuando los ejemplares son batidos por el oleaje (Guallart y Acevedo, 2006).

2. Se debe tener particular cuidado en no dañar el pie al separar el animal del sustrato. Si están desplazándose sobre una grieta y por lo tanto con el pie expuesto, a veces es posible capturarlos con la mano, simplemente haciendo presión con los dedos sobre la masa carnosa y separando el pie del sustrato; en estos casos, nunca debe intentarse tirando directamente de la concha, ya que en ocasiones se puede llegar a separar ésta de la masa carnosa y suponer por tanto la muerte del ejemplar. Se recomienda que, con el ejemplar fuera de su huella y la concha ligeramente levantada, se utilice un cuchillo de punta roma, haciendo palanca suave y ejerciendo presión con la punta al avanzar sobre el sustrato (Figura 1A), nunca sobre el lateral del pie del ejemplar (Figura 1B); al utilizar el cuchillo es recomendable insertarlo, siempre que sea posible, por la parte posterior o lateral del ejemplar, con el fin de minimizar la probabilidad de daño sobre la región cefálica. Se debe evitar avanzar con la punta del cuchillo directamente sobre el pie o intentar hacer palanca

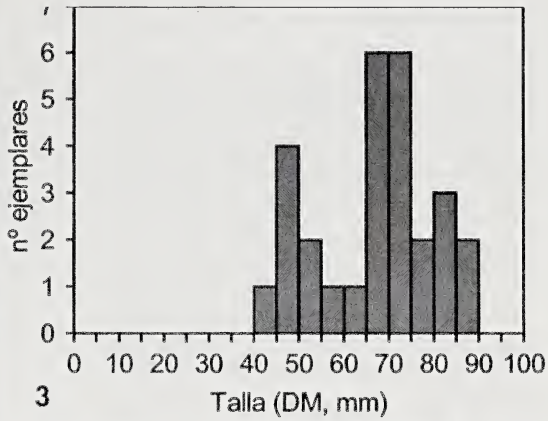

Figura 2. Ejemplar de *Patella ferruginea* tras la extracción de la muestra de tejido del manto (flecha). Figura 3. Distribución de frecuencia de tallas de los ejemplares de *Patella ferruginea* para los que se realizó la extracción de las muestras y se llevó a cabo el seguimiento posterior.
Figure 2. Patella ferruginea *specimen after removal of the sample from the mantle (arrow). Figure 3. Length frequency distribution of* Patella ferruginea *specimens for which sample extractions were performed and subsequently controlled.*

simplemente con éste para levantar la concha del ejemplar (Figura 1B)

3. Se debe registrar la posición y orientación en el sustrato del ejemplar en el momento de la captura, para ser devuelto después de la extracción exactamente en su ubicación original.

4. La obtención de la muestra de tejido debe tomarse del borde del manto del ejemplar, realizando un corte limpio mediante un bisturí (Figura 2). En general resulta suficiente extraer una muestra de menos de 10 mm^3 o de 10 mg. Algunos autores han llevado a cabo la obtención de este tipo de muestras en *P. ferruginea* no en el manto sino directamente en la masa muscular del pie (e.g. CASU *ET AL.*, 2011). Sin embargo, no hemos considerado aconsejable este procedimiento, pues la herida causada en el pie puede dificultar la adherencia posterior al sustrato de los ejemplares y, en definitiva, comprometer su supervivencia.

5. El proceso de la manipulación debe ser rápido: desde la separación del sustrato hasta su devolución al mismo debe transcurrir el menor tiempo posible, procurando que sea menor de 5 minutos.

En noviembre de 2010 se obtuvieron muestras de tejido siguiendo este procedimiento en 28 ejemplares de *P. ferruginea*, de un rango de talla entre 41,0 y 89,2 mm DM (diámetro máximo de la concha) y promedio (± desviación estándar) de 67,2 ± 13,6 mm DM (Figura 3). Con el fin de realizar un seguimiento de su supervivencia, y en el marco de otros trabajos experimentales, se llevó a cabo un marcaje de los ejemplares, adhiriendo sobre la concha piezas de plástico de colores, numeradas, mediante el uso de un adhesivo plástico de secado rápido de cianocrilato.

En junio de 2011, unos 8 meses más tarde, se pudieron localizar en el mismo lugar del litoral 26 de estos ejemplares. Esto supone una supervivencia del 92,9% de los ejemplares a los que se aplicó esta técnica. Ésta pudiera ser incluso superior si se considera que los 2 ejemplares que no se hallaron pudieran haber desaparecido por causas naturales (e.g. depredadores) o haber perdido la marca y haber cambiado la huella, lo cual habría imposibilitado su identificación.

Se plantea, por lo tanto, que el protocolo aquí expuesto sea el recomendado para la obtención de muestras de tejido para su uso en estudios genéticos o con otros fines, en ejemplares de esta especie protegida.

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Ponder W.F. 1988. The Truncatelloidean (= Rissoacean) radiation - a preliminary phylogeny. En Ponder, W.F. (Ed.): Prosobranch Phylogeny. *Malacological Review*, suppl. 4: 129-166.

Ros J. 1976. Catálogo provisional de los Opistobranquios (Gastropoda: Euthyneura) de las costas ibéricas. *Miscelánea Zoológica*, 3 (5): 21-51.

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Dendrodoris limbata (Cuvier, 1804)

Synonyms

Doris limbata Cuvier, 1804, *Ann. Mus. Hist. Nat. Paris*, 4 (24): 468-469 [Type locality: Marseille].

Doris nigricans Otto, 1823, *Nov. Act. Ac. Caes. Leop.-Car.*, 10: 275.

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ÍNDICE

Iberus 31 (2) 2013

RYALL P., HORRO J. & ROLÁN E. A revision of the genus *Genota* H. and A. Adams, 1853 (Gastropoda; Conoidea; Borsonidae) from West Africa
Revisión del género Genota *H. y A. Adams, 1853 (Gastropoda; Conoidea; Borsonidae) de África Occidental* 1-17

GUERRA A., CARO Mª.B., SEALEY M.J. AND LOZANO SOLDEVILLA F. Two new records of octopods in Canary Islands: *Amphioctopus burryi* (Voss, 1950) and *Macrotritopus defilippi* (Vérany, 1851) [Cephalopoda: Octopodidae]
Dos nuevos registros de pulpos en las islas Canarias: Amphioctopus burryi *(Voss, 1950) and* Macrotritopus defilippi *(Vérany, 1851) [Cephalopoda: Octopodidae]* 19-26

HOLYOAK D.T., HOLYOAK G.A., TORRES ALBA J.S., DA COSTA MENDES R.M. AND QUIÑONERO SALGADO S. *Succinea* (*Calcisuccinea*) sp., an American land-snail newly established in Portugal and Spain (Gastropoda: Succineidae)
Succinea (Calcisuccinea) *sp., un caracol terrestre americano nuevo para Portugal y España (Gastropoda: Succineidae)* 27-39

RUBIO F., FERNÁNDEZ-GARCÉS R. AND ROLÁN E. The genus *Haplocochlias* (Gastropoda, Skeneidae)
El género Haplocochlias *(Gastropoda, Skeneidae)* 41-126

SIBAJA-CORDERO J.A., GARCÍA-MÉNDEZ K. AND TRONCOSO J.S. Additions to the mollusk checklist of Cocos Island National Park, Costa Rica (Eastern Tropical Pacific)
Adiciones al catalogo de los moluscos del Parque Nacional Isla del Coco, Costa Rica (Pacifico Tropical Este) 127-163

PELORCE J., HORST D. ET HOARAU A. Une nouvelle espèce de la famille Aglajidae (Gastropoda: Opisthobranchia) des côtes de Méditerranée française
Una nueva especie de la familia Aglajidae (Gastropoda: Opisthobranchia) de la costa francesa del Mediterráneo 165-170

Notas breves

GUALLART J., ACEVEDO I., CALVO M. Y MACHORDOM A. Protocolo no letal para la obtención de muestras de tejido (para estudios genéticos) en la lapa amenazada *Patella ferruginea* (Gastropoda, Patellidae)
Non-lethal protocol for tissue-sampling (for genetic studies) in the endangered limpet Patella ferruginea *(Gastropoda, Patellidae)* 171-174

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